Synertek

Systems Corporation

VIM REFERENCE MANUAL

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Synertek Systems Corporation

P.O. BOX 552 SANTA CLARA, CALIFORNIA 95052 TEL. 408 988-5600 TWX: 910-338-0135

VIM-1 REFERENCE MANUAL

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* KIM is a product of MOS Technology, Inc.

CHAPTER 1

INTRODUCTION TO THE VIM COMPUTER

Whether you're a teacher or a student of computer science, a systems engineer or a hobbyist, you now own one of the most versatile and sophisticated single-board computers available today. The Synertek Systems VIM-1 is an ideal introduction to the expanding world of microprocessor technology as well as a powerful development tool for design of microcomputer-based systems. Fully assembled and thoroughly tested, the VIM-1 comes equipped with a 28-key dual-function keyboard for input and a 6-digit light emitting diode (LED) display for output. All that's needed to make your computer operational is a single 5-volt power supply.

Based on the popular and reliable 6502 Central Processing Unit (CPU), the VIM-1 is designed to permit flexible solutions to a wide range of application problems. A system monitor (SUPERMON) is stored in 4K bytes of Read Only Memory (ROM) furnished with the VIM-1 so you're free to concentrate on the application itself. But should you require customized system software, sockets are provided on the board for three additional ROM or Erasable PROM (EPROM) packages that can expand total ROM to 24K bytes. And by changing connections on the jumpers that have been designed for this purpose, the VIM-1 can be set up to respond to your own system software as soon as the power is turned on.

For working with data and programs, VIM-1 comes equipped with 1K of Random Access Memory (RAM), and sockets are available on the board for plug-in expansion up to 4K. Should additional memory be required for your application, an expansion port is provided which will allow additional ROM, PROM, RAM or I/O to be attached to the system up to the 65,536 maximum addressable limit for an 8-bit microprocessor.

While the keyboard and LED display included on the VIM-1 board will be sufficient for most users, other users may require the additional storage capability of audio cassette tape or the hard copy output of an RS-232 or a teletype terminal. Not only the serial interface, but also the hardware and software necessary for control of these devices is included on the VIM-1. Adding them to your system is simply a matter of properly wiring the appropriate connectors. Similarly, VIM-1 allows an oscilloscope to be added to the system to provide a unique 32-character display under software control. (Or, with the addition of the VIM-2 KB/TV interface and a common and inexpensive Radio Frequency (RF) adapter, you can turn your television set into a video display terminal.)

And that's not all. A total of 51 active Input-Output (I/O) lines (expandable to 71 with the addition of a plug-in component) permit an almost endless variety of other peripheral devices to interface to the VIM-1, from floppy disk drives to full-ASCII keyboards and other computer systems.

Other key hardware and software features of VIM-1 include jumper-selectable and program-controlled write protection for selected areas of memory, four internal timers (expandable to six), four on-board buffers for direct control of high voltage or high current interfaces, and a debug facility that may be controlled either by a manual switch or by software. We could go on, but rather than merely list what the VIM-1 is capable of doing, let's move on to the rest of the manual and learn how to put it to work.

CHAPTER 2

HOW TO USE THE VIM REFERENCE MANUAL

This manual is designed both to help you get your VIM-1 running and to teach you to use it as fully as possible. Reading over the following chapter descriptions will give you an idea of how to proceed and where to look for help when you run into a problem. Although to get the most out of this manual you should read it thoroughly before attempting to operate your VIM-1, only Chapter 3 is essential before applying power and attempting simple operations.

You should read Chapter 3 before you even unpack your VIM-1. Following the handling instructions in that chapter will help insure that you do not inadvertently damage the microcomputer components. Chapter 3 also contains instructions for connecting the power supply, and a simple keyboard exercise to acquaint you with the VIM-1 and verify that the system is working properly. In addition, directions are provided for attaching an audio cassette recorder, teletype or any RS-232 compatible terminal to the system.

Chapter 4 provides you an overview of the hardware and software features of the VIM-1. The major Integrated Circuit (IC) devices are described, and the configuration of the various edge connectors is explained. Memory assignment is also discussed, as are the various hardware jumper options on VIM-1. A complete list of machine language and assembly language commands for the 6502 CPU is included in this chapter.

Chapter 5 provides complete operating instructions for the VIM-1. The color-coded keyboard layout is explained, the keys and their functions are defined, and you're shown how to form VIM monitor commands. Instructions for operating an audio cassette recorder, teletype terminal with paper tape unit, and RS-232 terminal are included with the appropriate monitor command descriptions. In addition, the features of the VIM-1 monitor are explained in detail and a flowchart of monitor logic is included.

Chapter 6 is where you'll learn to program the VIM-1 to handle your applications. We'll describe the program flow and assembly code for a small sample program and explain how to prepare it for entry to the VIM-1. Then we'll discuss how to execute it and how to find problems in it if it doesn't work the way you expected it to work. After you've completed this example program, you'll have a chance to try your hand at two more programs of increasing complexity.

Chapter 7 describes how to use an oscilloscope with your VIM-1 module to obtain a unique, 32-character display similar to that of a CRT. The hardware is present on your VIM-1 to allow this usage, and the software has been designed to allow you to write your own program to send characters to the oscilloscope. A sample program implementing this feature is discussed in the chapter.

Chapter 8 explains how to expand your VIM-1 system to include additional memory or peripheral devices. I/O techniques are also discussed, including how to configure an auxiliary expansion port.

Chapter 9 consists of a discussion of advanced monitor and progamming techniques which will add flexibility and expandability to your VIM system. One of the unique things about the VIM-1 is its seemingly endless flexibility in software. For example,

you can create a sub-set of new monitor commands or an entirely new monitor by taking advantage of the way the system handles unrecognized commands. You can also make use of nearly all of the monitor as subroutines in your own programs, thus saving both programming time and memory space.

In addition to the chapters described above, several appendices located at the back of the manual include important service and other reference information. Appendix A explains what to do if your VIM-1 does not operate properly, becomes defective or requires service. Appendix B contains a complete parts list and a component layout diagram. Audio cassette tape formats are described in Appendix C, and the format for data stored on punched paper tape is outlined in Appendix D.

You will find that your VIM-1 will interface many devices designed to accompany the KIM computer. This compatability with KIM-related products is described in Appendix E. Appendix F explains how to create and use a sync tape for audio cassette operation. Finally, Appendices G, H, I and J provide reference information on the SY6502, SY6522, SY6532 and SY2114 RAM IC devices.

The last item in the manual, which is not an appendix but an addendum, is a complete listing of the VIM-1 SUPERMON monitor program. Nothing is held back; you have the complete listing to allow you to modify it any way you wish. Once you understand how the monitor works and the essentials of 6502 assembly language programming, this listing becomes an invaluable tool for implementing your own applications.

CHAPTER 3

PREPARING TO USE YOUR VIM COMPUTER

This chapter will take you, step-by-step, through the process of unpacking the VIM-1 and making it operational. After applying power and checking to see that the keyboard and display function properly, you will learn how to attach an audio cassette recorder, TTY, or CRT to the system.

3.1 PARTS CHECK

In addition to this manual, several other items are included with your microcomputer. Packed along with the VIM-1 microcomputer itself you should find a programming card containing a summary of 6502 instruction codes and VIM commands, a programming manual, a warranty card, which you should fill out and mail to Synertek Systems as soon as possible, an optional user club card and two edge connectors, one long and one short. Also included is a red plastic strip which serves as a faceplate over the lighted display. The terms of the warranty are explained on the warranty card. Also included with the computer is a packet of small rubber feet on which to mount your VIM-1 for table-top operation.

3.2 CAUTION ON MOS PARTS

The integrated circuits on your VIM-1 are implemented with Metal Oxide Silicon (MOS) technology and may be damaged or destroyed if accidentally exposed to high voltage levels. By observing a few simple precautions you can avoid a costly and disappointing mishap.

Static electricity is perhaps the least obvious, and thus most dangerous, source of voltage potential that can damage computer components. The VIM-1 is wrapped in special conductive material to protect it in shipping, and you should be careful to discharge any possible build-up of static electricity on your body before unpacking or handling the circuit board. Walking on a carpeted floor is especially liable to produce static electricity. Always touch a ground connection such as a metal window frame or an appliance with a three-pronged plug before handling your VIM-1, and avoid touching the pin connections on the back of the circuit board. Ungrounded or poorly grounded test equipment and soldering irons are other sources of potentially dangerous voltage levels. Make sure that all test equipment and soldering irons are properly grounded.

3.3 VISUAL CHECK

While observing the precautions described in section 3.2, take the VIM-1 from its box and remove the protective packing. Next, apply the small rubber mounting feet and place the VIM-1 on a flat surface with the keyboard facing you. Using Figure 3-1 you can identify the major system components and begin to familiarize yourself with the layout of the VIM-1 board. Chapter 4 describes the system in more detail, with appropriate schematics, but for now we're just concerned with powering-up and beginning operation.

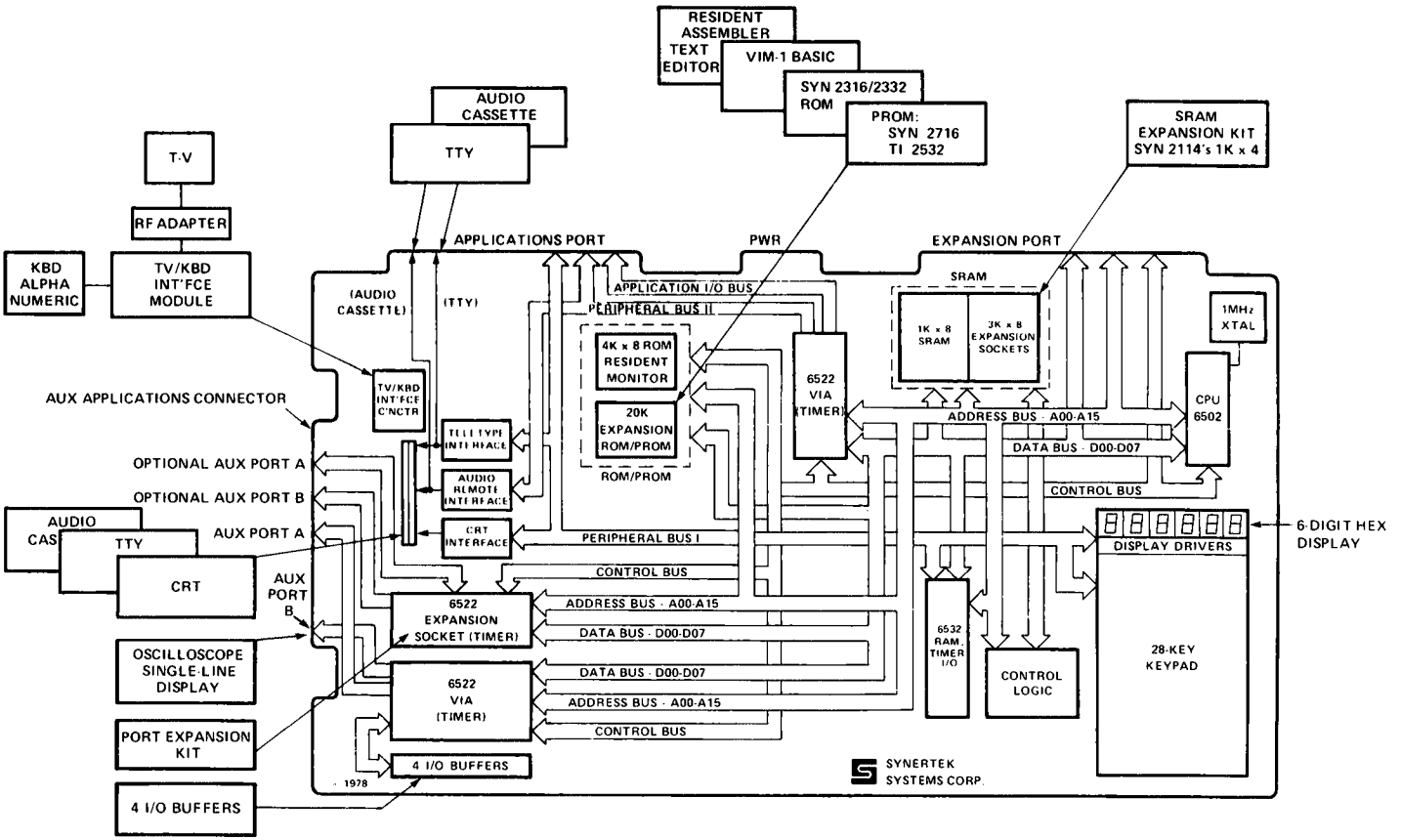


Figure 3-1. FUNCTIONAL BLOCK DIAGRAM

3.4 RECOMMENDED POWER SUPPLIES

The VIM-1 microcomputer requires only the addition of a power supply to become fully operational. Any unit that supplies +5 Volts DC @ 1.5 amps and has adequate overload protection is acceptable. Synertek Systems does not recommend any particular make or model. Rather than buy an assembled power supply, you may want to build your own from one of the many kits available from hobby stores and mail order houses.

3.5 POWER SUPPLY CONNECTION

Now that you've obtained a 5-volt power supply, you're almost ready to power-up the VIM-1. Find the power supply edge connector (the smaller of the two edge connectors packed along with the microcomputer), and wire it as shown in Figure 3-2. Next, slide the connector onto the power connector pins located in the middle of the top edge of the board. Check to make sure that the wiring is correct and that the connector is properly oriented before attaching it to the board.

3.6 POWER-ON CHECK

Turn on the power supply. The red light to the left of the power connection should glow to indicate that power is reaching the board. The LED display above the keyboard should be completely blank, and a tone should be heard. Press the Carriage Return (CR) key. You should again hear the audible tone that is emitted when power is turned on or a key depression is sensed, and the display should show "SY1.0 . .". Carriage Return (CR) is the key that "logs you on" to the computer when first powering up or after pressing Reset (RST). If your computer isn't responding properly, turn off the power supply. Remove the power connector from the board and make sure that all wires are connected to the proper locations and are securely attached, then repeat the power-up procedure.

If after you recheck and repeat the power-up procedure, your VIM-1 does not respond as described above, refer to Appendix A for information on returning the unit for service.

3.7 KEYBOARD EXERCISE

Now that your VIM-1 is operational, let's try a small program to verify that the system is functioning properly. The program will add together two 8-bit binary numbers and store the result. As you enter the program, addresses and data will appear on the LED display as hexadecimal digits. Addresses are 16 bits long and thus will be represented by four hexadecimal digits, while data bytes are 8 bits long and will appear as two hex digits. Before entering the program, you may want to review the following listing of assembler code for the test program. The process of converting assembler code to machine language will be explained in Chapter 6.

```
                                MONITR  =  $8000
                                VALUE1  =  $0200
                                VALUE2  =  $0201
                                RESULT  =  $0202
                                   *    =  $0203
0203  18                        START      CLC
0204  D8                                   CLD
0205  AD 00 02                             LDA   VALUE1
0208  6D 01 02                             ADC   VALUE2
020B  8D 02 02                             STA    RESULT
020E  4C 00 80                             JMP   MONITR
                                           END
```

POWER SUPPLY CONNECTIONS

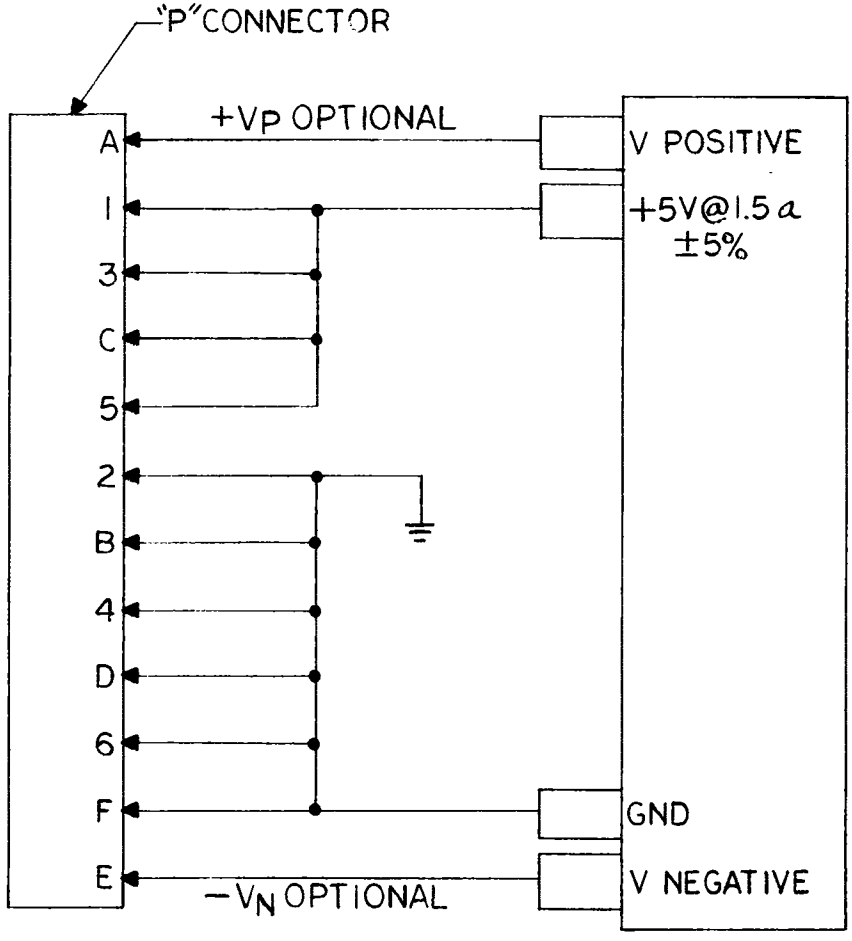


Figure 3-2. POWER SUPPLY CONNECTIONS

Now enter the program by following the steps listed below. Asterisks indicate the displayed data contained in the identified locations. Simulated key tops stand for function keys (e.g., (CR) for carriage return) The period displayed at the end of each entry sequence is SUPERMON's standard prompt character. As each data byte is entered, the address will automatically increment.

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(RESET)		
(CR)	SY1.0..	Keyboard log-on
(MEM) 200 (CR)	0200.**.	Display contents of location 0200.
C1	0201.**.	Store C1 (Hex) in 0200, display next location.
05	0202.**.	Store 05 (Hex) in 0201, display contents of 0202.
00	0203.**.	Store 00 (Hex) in 0202, display 0203
Enter Program:		
18	0204.**.	Store 18 (Hex) in 0203, display 0204
D8	0205.**.	Store D8 (Hex) in 0204, display 0205
AD	0206.**.	.
00	0207.**.	.
02	0208.**.	.
6D	0209.**.	.
01	020A.**.	
02	020B.**.	
8D	020C.**.	
02	020D.**.	
02	020E.**.	
4C	020F.**.	
00	0210.**.	
80	0211.**.	
(CR)	211.**..	
Check to see that program is entered correctly:		
(MEM) 200 (CR)	0200.C1.	VALUE1
(→)	0201.05.	VALUE2
(→)	0202.00.	RESULT
(→)	0203.18.	Clear carry flag
(→)	0204.D8.	Set status register for binary add
(→)	0205.AD.	Load VALUE1 into accumulator
(→)	0206.00.	Address of VALUE1, low order byte
(→)	0207.02.	Address of VALUE1, high order byte
(→)	0208.6D.	Add VALUE2 to accumulator
(→)	0209.01.	Address of VALUE2, low order byte
(→)	020A.02.	Address of VALUE2, high order byte
(→)	020B.8D.	Store accumulator
(→)	020C.02.	Address of RESULT, low order byte
(→)	020D.02.	Address of RESULT, high order byte
(→)	020E.4C.	JUMP to monitor
(→)	020F.00.	Address of monitor, low order byte
(→)	0210.80.	Address of monitor, high order byte
(CR)	210.80..	Exit from memory display and modify mode

Your program is now entered and ready to execute. The two numbers you will add together, C1 (Hex) and 05 (Hex), are stored in locations 0200 and 0201 respectively. The result will be stored in location 0202. The two digit hex codes you entered in

succeeding memory locations are the addresses, operands, and 6502 instruction codes necessary to add together two 8-bit binary numbers and return to the monitor program. To execute the program and display the result, perform the following steps:

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(GO) 203 (CR)	g 203 .	Execute program starting at location 0203
(MEM) 202 (CR)	0202.C6	Check result stored in location 0202
(CR)	202.C6. .	Exit from memory display and modify mode

Although this is a simple problem, it demonstrates the basic procedures for entering and executing a program on the VIM-1 as well as verifying that the system is operating properly.

3.8 ATTACHING AN AUDIO CASSETTE RECORDER

The program you entered in section 3.7 will remain stored in RAM memory only as long as the power remains on. As soon as the power is turned off, RAM data is lost, so to reuse the program you would have to enter it again from the keyboard. In order to provide you with a way to permanently store data and programs, VIM-1 is equipped with the hardware and software logic necessary to "talk to" an audio cassette recorder.

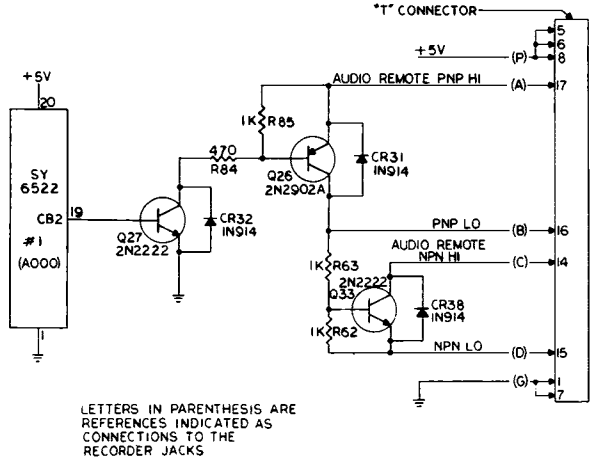
Since VIM-1 audio cassette operation involves high data transfer rates (185 bytes per second for HIGH-SPEED format), you should use a good quality recorder to ensure reliable performance. The unit should be equipped with an earphone jack for output, a microphone for input, a remote jack for remote control of the motor (optional), and standard controls for Play, Record, Rewind, and Stop. An additional feature that is useful but not essential is a tape counter. By keeping a record of counter values you can locate any program of data block manually without having to search the tape under program control at Play speed.

VIM-1 is designed to allow the cassette unit to be attached to either the Applications (A) or the Terminal (T) connector (requires a DB25 connector; see section 3.12). Refer to Figure 3-1 for the board location of these two connectors. Figure 4-3 shows how the Applications (A) edge connector should be wired for the cassette unit. The Terminal (T) connector should be wired as shown in Figure 4-3 if the unit is to be attached to the T connector. Keep the leads as short as possible and avoid running them near sources of electrical interference such as AC power cords. Always use the ground connection at the connector and do not ground directly to the power supply.

The remote control circuitry on the VIM-1 card allows a variety of cassette recorders to be used under software control. However, before you connect your remote control you must determine which type of connection is necessary for your particular recorder. Figure 3-3 illustrates the VIM-1 circuitry and eight different ways to hook it up. The following procedure can be used to determine which connection is necessary for your recorder:

1. Insert the remote control cable into your recorder. Install a tape in the unit.
2. Press play. The tape should not move. If it does, check the cable.
3. Measure the voltage at the center tip of the open end of the cable. (See Figure 3-4. Use ground reference from the MONITOR OUT plug.) Record

AUDIO CASSETTE VIM REMOTE CONTROL CONNECTION



AUDIO CASSETTE RECORDER JACKS REMOTE CONTROL CONNECTIONS

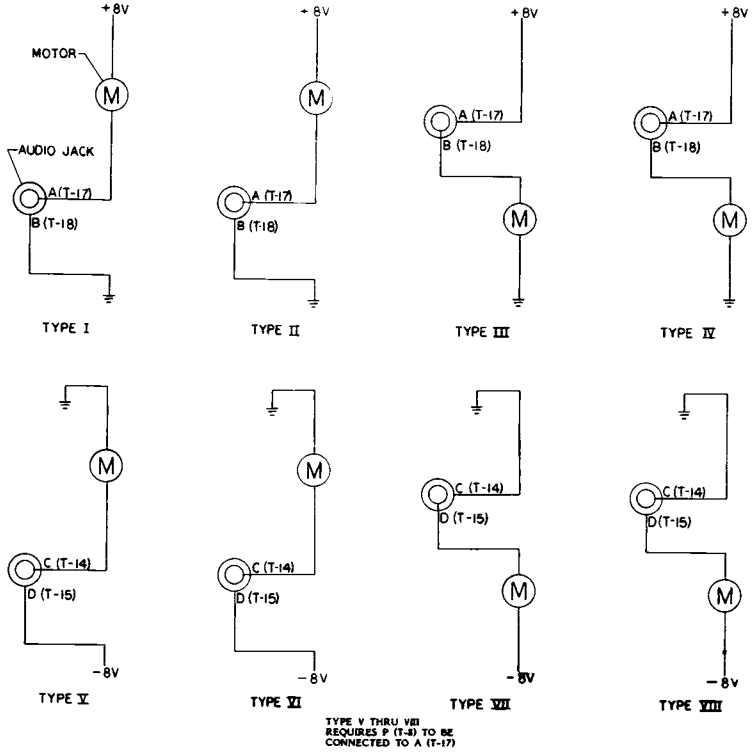


Figure 3-3. REMOTE CONTROL TYPES AND CONNECTIONS

REMOTE CONTROL PLUG UNIT

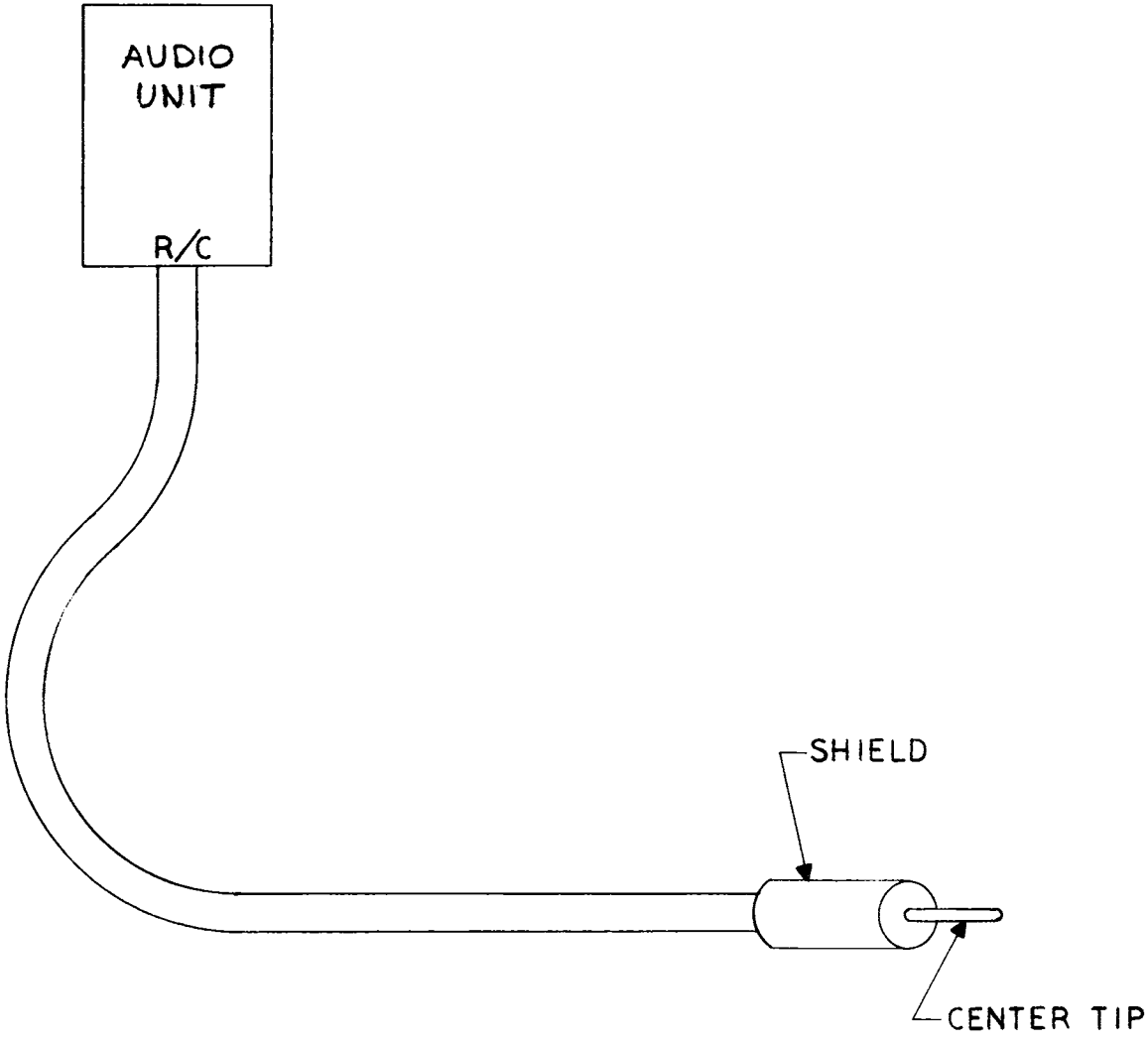


Figure 3-4. REMOTE CONTROL PLUG UNIT

this as Reading A. Typically this will be either +6 to +8 volts, -6 to -8 volts, or ground.

4. Measure voltage at the shield of the open end of the cable. Record this as Reading B. The same typical values stated in step 3 will apply. Readings A and B should not be the same.
5. Using a wire jumper, short the shield and center tip together. Your tape should now move. Measure the voltage at the center tip (do not remove the short). Record this as Reading C.
6. If your tape moves in step 2 or your tape does not move in step 5, check your cable for opens or shorts.
7. Use Table 3-1 to determine which type of connections to make for your recorder.
8. After you have found the proper category for your recorder, Figure 3-3 illustrates which connections to make.

3.9 SAVE AND LOAD EXERCISE

To check cassette unit operation, we'll "Save" on tape the program presented in Section 3.7, then load the program back into RAM. But before beginning tape operations, we must set the volume and tone controls on the recorder to the correct position. This is accomplished by creating and using a "sync" tape as described in Appendix F. Follow those procedures now, keeping in mind that we will save the program, and thus will also load it back into RAM, in HIGH-SPEED format.

After adjusting you recorder, enter the program from the keyboard as you did before. Insert a tape into the recorder. If your unit is equipped with remote control, place it in Record mode. Since the motor for the cassette is under software control, the tape will not advance. If your unit does not have remote control, do not place the unit in Record mode until just before pressing (CR) while entering the save command shown below including the carriage return, before placing the unit in Play Mode.

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(SAV 2) 3 (-) 200 (-) 210 (CR)	0-210.	Save locations 0200 to 0210 in a record with ID=03, in HIGH-SPEED format.

When recording starts the display will go blank. When recording is completed the display will re-light. All this should take approximately eight seconds. If your unit does not have remote control, stop the tape manually after the display re-lights.

Now rewind the tape to the starting point. If your unit has remote control, you will have to pull out the Remote jack from the recorder or keep your finger on the RST key.

To destroy the program stored in RAM, turn off system power, then turn it on again.

Log back onto the computer by pressing (CR), then place the cassette unit in Play mode if it is equipped with remote control. If you are operating the controls manually, you should first enter the load command shown below.

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(LD 2) 3 (CR)	..L3	Load HIGH-SPEED tape record with ID=03 into memory.

This command directs the VIM-1 to search for the tape record with ID=03. While the VIM-1 is searching, an "S" will be displayed. When reading begins, the AUDIO indicator LED will glow and the display should go blank. When the specified record has been loaded into memory the display will re-light.

If you are operating the controls manually, turn the recorder OFF. Under remote control, the motor will stop automatically.

Now follow the instructions in Section 3.7 for executing the program. The result of the addition, C6 (Hex), should appear on the display. If the "S" did not disappear when reading in the program, or if the cassette otherwise did not respond as described above, check all wiring connections, verify the settings of the volume and tone controls and repeat the recording and playback procedures, making sure that each step is performed correctly. If after rechecking connections and repeating the procedure you are still unsuccessful, refer to Appendix A.

3.10 ATTACHING A TTY

To enable you to add a hard copy output device to your system, VIM-1 interfaces to a TTY terminal. Since the Teletype Model 33ASR is widely used and easily obtained, it will be used in the procedures and diagrams in this section. To interface other terminals, use the information given in this section as a general guide and consult the terminal instruction manual for different wiring and connection options.

Your TTY should be set for 20 mA current-loop operation. If it is not, follow the manufacturer's instructions for establishing this configuration. In addition, check to make sure that your TTY is set up to operate in full-duplex mode. You need not concern yourself with the TTY data transmission rate. VIM-1 assumes 110 bits-per-second (baud) for TTY terminals.

Just like an audio cassette recorder, a TTY may be attached to either the Applications (A) connector or using a DB25 (see section 3.12), to the Terminal (T) connector connection (See Figure 3-1). Figure 3-5A shows how the edge connector should be wired if the TTY will be attached to the "A" connector. Figure 3-5B shows the proper connections if it will be attached to the "T" connector. Wire the edge connector as appropriate for your application, then slide it into position. To "log on" to the terminal enter the following command at the on-board keyboard (not on the TTY keyboard).

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(RESET)		
(CR)	SY1.0 . .	Log-on to keyboard
(SHIFT) (JUMP) 1 (CR)	blank	Log-on to TTY

The TTY should respond with a carriage return and the TTY prompt character, a period. If it does not, turn off the power and re-check your connections, then power-up again.

3.11 TERMINAL EXERCISE

After the TTY prints the prompting character (".") as shown on the first line of the chart below, perform the rest of the steps listed to become acquainted with TTY operation. You will be entering a portion of the program presented in Section 3.7.

TTY I/O CONNECTIONS

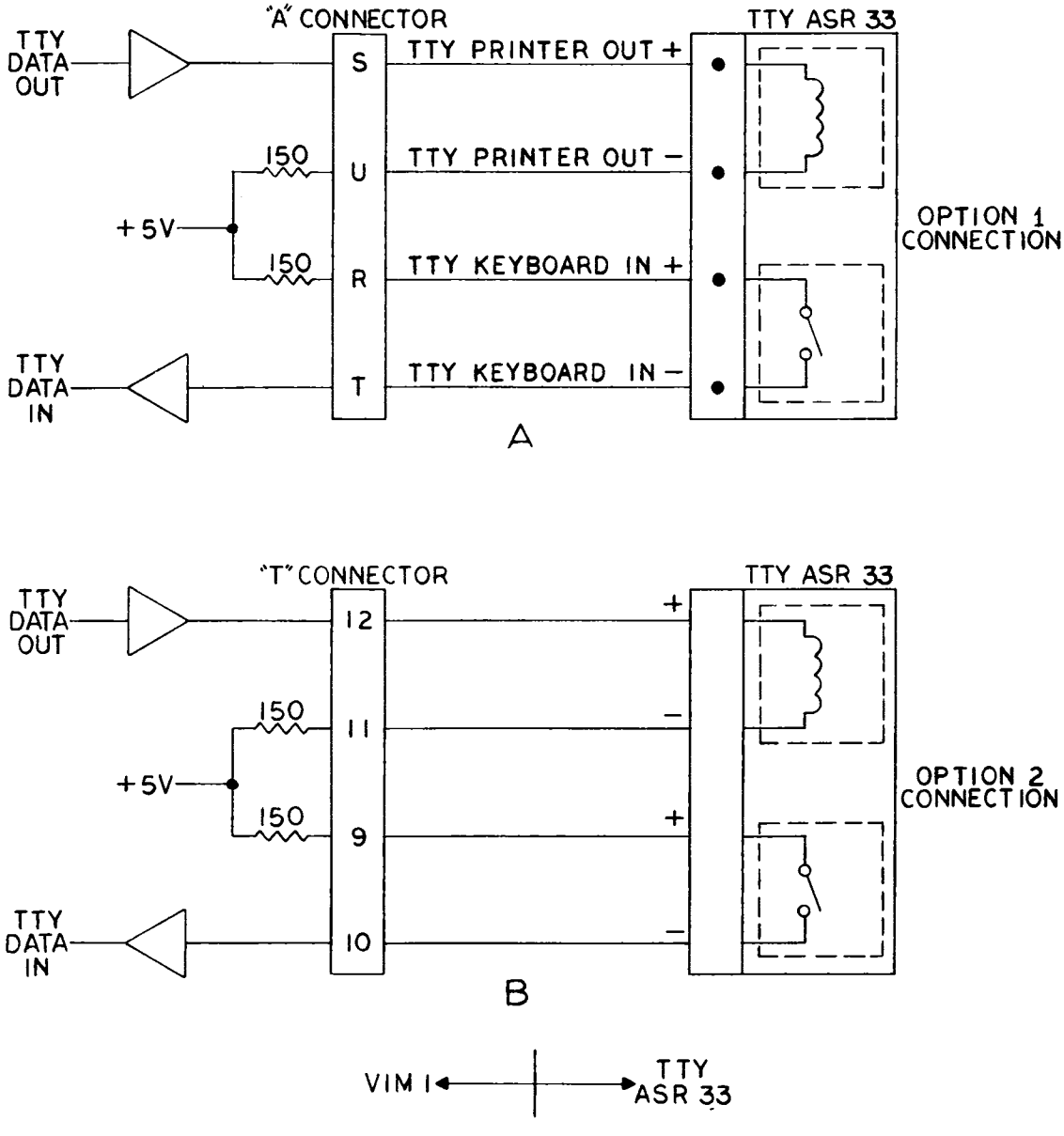


Figure 3-5. TTY I/O CONNECTIONS

YOU KEY IN	TTY PRINTS	EXPLANATION
	.	Prompt
M 200 (RETURN)	.M 200 0200,**,	Display contents of location 0200
C1	0200,**,C1 0201,**,	Store C1 (Hex) in 0200, display 0201
05	0201,**,05 0202,**,	Store 05 (Hex) in 0201, display 0202
(RETURN)	.	Return to monitor

3.12 ATTACHING A CRT

VIM-1 is equipped with an RS-232 interface to facilitate the use of such RS-232 devices as a full-ASCII keyboard and CRT display. Figure 3-6 shows how the proper DB25 connector, which may be easily obtained from an electronics supply house or computer hobby store, should be wired. The location of the interface on the VIM-1 board is show in Figure 3-1. Some older units may need to be wired differently. Refer to the section on jumper options in Chapter 4.

3.13 CRT EXERCISE

Operating a CRT terminal is very similar to operating a TTY. Names of keys and their functions may vary slightly depending on the device, so you should consult your CRT operating manual to find which keys correspond to the TTY keys used in the exercise in section 3.11. VIM-1 automatically adjusts to data transmission rates of 300, 600, 1200, 2400, or 4800 baud for CRT operation. To set the baud rate, enter a "Q" on the CRT keyboard after powering-up (do not press any on-board keys). The CRT should respond with a ".", the terminal prompt character. Now repeat the exercise in Section 3.11 using the CRT keyboard.

In this chapter you have made your VIM-1 operational and learned how to attach several peripheral devices to the system. Let's move on to Chapter 4 and examine in detail the various features of VIM-1 hardware and software.

CRT I/O CONNECTIONS

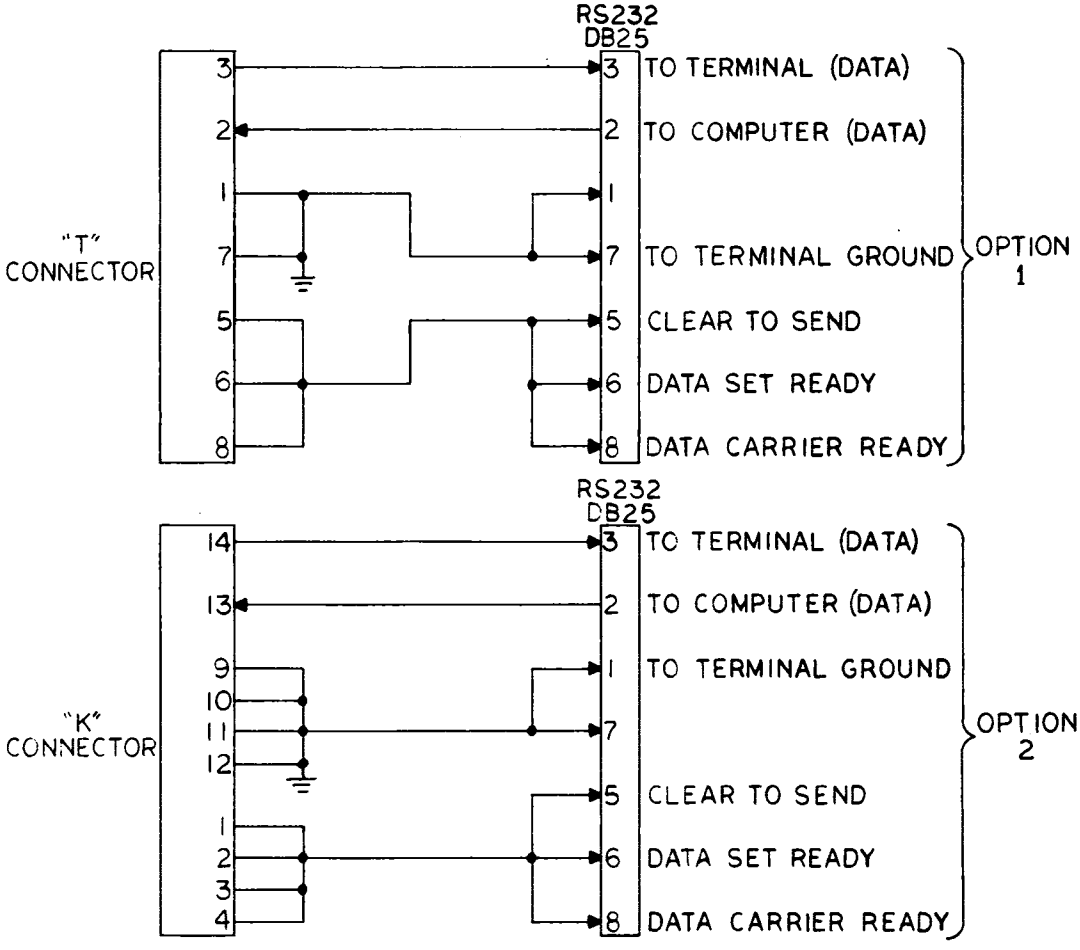


Figure 3-6. CRT I/O CONNECTIONS

CHAPTER 4

VIM-1 SYSTEM OVERVIEW

This chapter will describe your VIM-1 microcomputer system's hardware and software in sufficient detail to allow you to understand its theory of operation. Each Integrated Circuit (IC) component on the VIM-1 board is discussed and related to a functional block diagram. Each functional module is then discussed schematically and the I/O connectors are described. The system memory is then covered and the software is discussed briefly. Detailed data on the software itself is found in Chapter 5 of this manual.

4.1 HARDWARE DESCRIPTION

The VIM-1 microcomputer consists primarily of a 6502 CPU, one or more 6522 Variable Interface Adapters (VIA), a 6532 Memory and I/O Controller and two types of memory involving any combination of several different components. Because of the flexibility of the memory structure, it is discussed in a separate section (4.2, below).

In any microcomputer system, all the components work together functionally as well as being physically interconnected. These connections are illustrated in Figure 4-1, a block diagram of the VIM-1 microcomputer system.

4.1.1 6502 CPU Description

The Central Processing Unit (CPU) of the VIM-1 microcomputer system is the 6502 microprocessor which is designed around a basic two-bus architecture--one full 16-bit address bus and an eight-bit data bus. Two types of interrupts are also available on the processor. Packaged in a 40-pin dual-in-line package, the 6502 offers a built-in oscillator and clock drivers. Additionally, the 6502 provides a synchronization signal which indicates when the processor is fetching an instruction (operation code) from program memory.

During the following discussion of the 6502, you should refer to the Data Sheets in this manual, which describe the pin connections for all three of the major types of devices present on the VIM-1 microprocessor system.

4.1.1.1 Bus Structure. The 6502 CPU is organized around two main busses, each of which consists of a separate set of parallel paths which can be used to transfer binary information between the components and devices in the VIM-1 system. The address bus transfers the address generated by the processor to the address inputs of the peripheral interface and memory devices (i.e., the 6522 and 6532 components). Note that in the Data Sheet for the 6502, the address lines originate at pins 9-20 and 22-25 of the 6502 CPU. These address lines go to pins 2-17 on the 6522 and/or to pins 2, 5-8, 10-15 and 34-40 on the 6532. Since the processor is almost always the only source of address generation in a system, an address bus is generally referred to as "unidirectional." That is the case with the VIM-1 microcomputer system. Since the address bus consists of 16 lines, the processor may read and write to a total of 65,536 bytes of storage (i.e., program memory words, RAM words, stack, I/O devices and other information), a condition which is normally referred to as a "64K memory capacity."

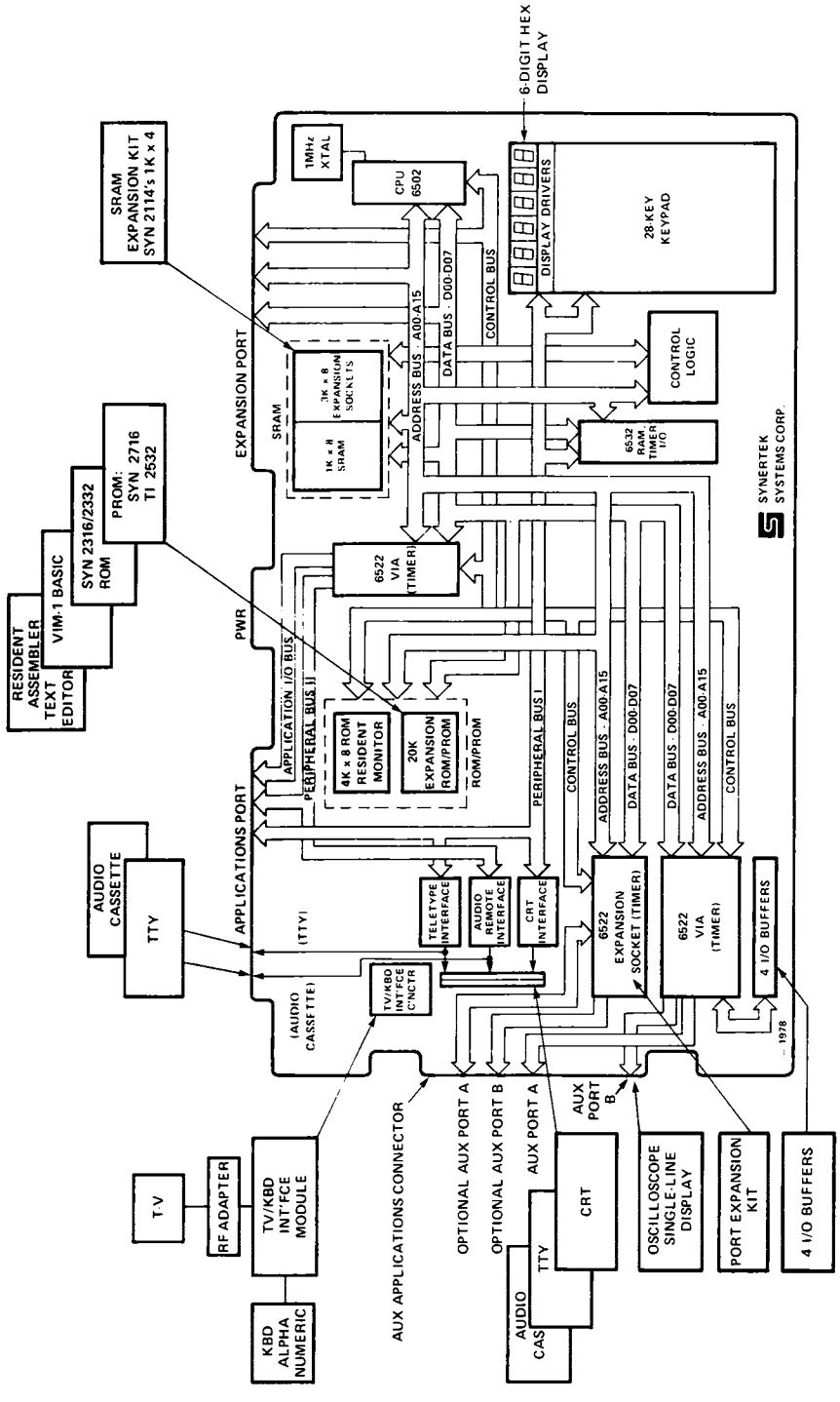


Figure 4-1. FUNCTIONAL BLOCK DIAGRAM

The other bus in the 6502 processor is called the data bus. It is an eight-bit bidirectional data path between the processor and the memory and interface devices. When data is moved from the processor to a memory location, the system performs a write; when the data is traveling from memory to the CPU, a read is being performed. Pins 26-33 on the 6502, 6522 and 6532 devices are all data lines connected to the data bus. The direction of the transfer of data between these pin connectors is determined by the output of the Read/Write (R/W, Pin 34) of the 6502. This line enables a write memory when it is "low" (when its voltage is below 0.4 VDC). Write is disabled and all data transfers will take place from memory to the CPU if the level is high (greater than 2.4 VDC).

One of the important aspects of the 6502 CPU is that it has two interrupt input lines available, Interrupt Request (labeled $\overline{IRQ}$ in the Data Sheet) and a Non-Maskable Interrupt (labelled $\overline{NMI}$).

Interrupt handling is one of the key aspects of microprocessor system design. Although the idea of interrupt handling is fairly simple, a complicating factor is the necessity for the processor to be able to handle multiple interrupts in order of priority (usually determined by the programmer) and not "losing track" of any of them in the process. These are concepts which you as a programmer-user of the VIM-1 will be concerned with only in advanced applications. The handling of user-generated interrupts is discussed elsewhere in this manual. If you do have occasion to alter pre-determined interrupt handling, it will be helpful for you to understand how the process works for the two types of interrupts in the 6502.

There are two main differences between the $\overline{IRQ}$ and $\overline{NMI}$ signals and their handling. First, $\overline{IRQ}$ will interrupt the CPU only if a specific flag--the Interrupt Disable Flag (I)--in the system's Processor Status Register is cleared, i.e., zero. If this flag is "set"--i.e., one--the $\overline{IRQ}$ is disabled until the flag is cleared. But an $\overline{NMI}$ request (as its name implies) always causes an interrupt, regardless of the status of the I-flag. The other main difference between the two types of interrupts is that the $\overline{IRQ}$ interrupt is "level sensitive." Any time the signal is less than 0.4 VDC and the Interrupt Disable flag is cleared, an interrupt will take place. In the case of $\overline{NMI}$, the interrupt is said to be "edge-sensitive" because it is dependent on a sequence of timing events. This interrupt will occur only if the signal goes "high" (i.e., exceeds 2.4 VDC) and then goes back to ground (less than 0.4 VDC). The interrupt occurs on the negative-going transition past 0.4 V.

The Data Sheet contains a summary of the 40 pins on the 6502 CPU and their function. Note that three of the pins--5, 35 and 36--are not connected on the 6502.

4.1.1.2 Summary. The 6502 CPU is a versatile processor. It was selected for your VIM-1 microprocessor system because of its overall functional characteristics, which facilitate its use in a wide variety of applications. Its role in the VIM-1 system will become clearer when we discuss programming and software in Section 4.3 and in Chapters 5 and 6.

4.1.2 6522 Description

The SY6522 Versatile Interface Adapter (VIA) is a highly flexible component used on the VIM-1 module to handle peripheral interfaces. Two of these devices are standard components on your VIM-1; a third may be added merely by plugging it into the socket (U28) provided. Control of the peripheral devices is handled primarily through the two eight-bit bi-directional ports. Each line of these ports can be programmed to act as

either an input or an output. Also, several of the peripheral I/O lines can be controlled directly from the two very powerful interval timers integrated into the chip. This results in the capability to 1) generate programmable frequencies, 2) count externally generated pulses, and 3) to time and monitor real time events.

A description of the pin designations on the SY6522 is contained in the Data Sheet enclosed with your VIM-1. It should be used in following the discussion of the operation of the component in the VIM-1 module which follows. The Memory Map of the VIM-1 module (Figure 4-10) will also be helpful during this discussion.

4.1.2.1 Processor Interface. Data transfers between the SY6522 and the CPU (6502) take place over the eight-bit data bus (DB0-DB7) only while the Phase Two Clock ($\phi 2$) is high and the chip is selected (i.e., when CS1 is high and $\overline{CS2}$ is low). The direction of these data transfers is controlled by the Read/Write line (R/W). When this line is low, data will be transferred out of the processor into the selected 6522 register; when R/W is high and the chip is selected, data will be transferred out of the SY6522. The former operation is described as the write operation, the latter the read operation.

Four Register Select lines (RS0-RS3) are connected to the processor's address bus to allow the processor to select the internal SY6522 register which is to be accessed. There are 16 possible combinations of these four bits and each combination accesses a specific register. Because of the fact that the SY6522 is a programmable-addressable device, these RS line settings, in combination with the basic device address, form the specific register address shown in the 6522 Data Sheet.

Two other lines are used in the SY6522 interface to the 6502 processor. The Reset line ($\overline{RES}$) clears all internal registers to a logical zero state (except T1, T2 and SR), placing all peripheral lines in the input state. It also disables the timers, shift register and other on-chip functions and disables interrupting from the chip. The Interrupt Request line ($\overline{IRQ}$) generates a potential interrupt to the CPU when an internal interrupt flag is set and a corresponding interrupt enable bit is set to a logical "1." The resulting output signal is then "wire or'ed" with other similar signals in the system to determine when and whether to interrupt the processor.

4.1.2.2 Peripheral Interface. As we mentioned earlier, peripheral interface is handled largely over two eight-bit ports, with each of the 16 lines individually programmable to act as an input or output line. Port A consists of lines PA0-PA7 and Port B of lines PB0-PB7.

Three registers are used to access each of the eight-bit peripheral ports. Each port has a Data Direction Register (DDRA and DDRB), which is used in specifying whether the pins are to act as inputs or outputs. If a particular bit in the Data Direction Register is set to zero, the corresponding peripheral pin is acting as an input; if it is set to "1," the pin acts as an output point.

Each of the 16 peripheral pins is also controlled by a bit in the output register (ORA and ORB) and a similar bit in the Input Register (IRA and IRB). When the pin is programmed to act as an output, the voltage on the pin is controlled by the corresponding bit in the Output Register. A "1" in the appropriate Output Register causes the pin to go "high" (2.4 VDC or higher), and a zero causes it to go "low (0.4 VDC or lower).

Functionally, reading a peripheral port causes the contents of the appropriate Input Register to be transferred to the Data Bus.

The SY6522 has a number of sophisticated features which allow very positive control of data transfers between the processor and peripheral devices through the operation of "handshake" lines which involve the use of Peripheral Control Lines (CA1-CA2 and CB1-CB2). These operations are beyond the scope of this manual; if you are interested in further information, you should consult the data sheet enclosed.

4.1.3 6532 Description

Like the SY6522 described above, the SY6532 is used on the VIM-1 module to control peripheral interface. Only one SY6532 is furnished with your VIM-1 and no others are provided for.

From an operational standpoint, the SY6532 is quite similar to the SY6522. One key difference, particularly on your VIM-1 module, is the presence of a 128-byte x 8-bit RAM within the SY6522. This is the location referred to as "System RAM" in discussions of the software operation and in the Memory Map (Figure 4-10).

A description of the pin designations on the SY6532 is included in the enclosed Data Sheet. You will notice that, like the SY6522, the SY6532 contains 16 peripheral I/O pins divided into two eight-bit ports (lines PA0-PA7 and PB0-PB7). Each of these pins can be individually programmed to function in input or output mode. $\overline{IRQ}$ on the VIM-1 SY6532 is not connected.

The Address lines (A0-A6) are used with the RAM Select ($\overline{RS}$) line and the Chip Select lines (CS1 and $\overline{CS2}$) to address the SY6532. It is in this addressing that the SY6532 differs somewhat from the SY6522's on your VIM-1 module. To address the 128-byte RAM on the SY6532, CS1 must be high and $\overline{CS2}$ and $\overline{RS}$ must both be low. To address the I/O lines and the self-contained interval timer, CS1 and $\overline{RS}$ must be high and $\overline{CS2}$ must be low. In other words, CS1 is high and $\overline{CS2}$ is low to address the chip; $\overline{RS}$ is used to differentiate between addressing RAM and the I/O Interval Timer functions. Distinguishing between I/O lines and the Interval Timer is the function of Address Line 2 (A2), which is high to address the timer and low to address the I/O section. Again, the Memory Map in Figure 4-10 clarifies these operations since they are largely software-directed and address-dependent.

4.1.4 Functional Schematics

Understanding the electrical interfaces among the various components may be of some interest to you as you use and expand your VIM-1 microcomputer. The figures on the following pages include segmented schematics, where each figure provides an electronic overview of the interface between the CPU and its related component devices and peripherals.

Table 4-1 describes the contents of each figure in this group of schematic segments.

Table 4-1. INDEX OF SCHEMATIC SEGMENTS FIGURES 4-2 TO 4-9

Figure	Function/Segment Diagrammed
4-2	TTY and CRT Interface
4-3	Audio Cassette Interface
4-4	Audio Cassette Remote Control
4-5	I/O Buffer
4-6	Keyboard/Display
4-7	Control Section
4-8	Memory Section
4-9	Oscilloscope Output Driver

Table 4-2 provides, in summary form, a list of the connector points on the four VIM-1 connectors. This allows you to determine pin and connector configurations for various application options.

Key:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Component Side
	A	B	C	D	E	F	H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z	Solder Side

EXPANSION (E)

1	SYNC	A	AB0
2	RDY	B	AB1
3	Ø1	C	AB2
4	IRQ	D	AB3
5	RO	E	AB4
6	NMI	F	AB5
7	RES	H	AB6
8	DB7	J	AB7
9	DB6	K	AB8
10	DB5	L	AB9
11	DB4	M	AB10
12	DB3	N	AB11
13	DB2	P	AB12
14	DB1	R	AB13
15	DB0	S	AB14
16	30	T	AB15
17	DBOUT (1)	U	Ø2
18	POR	V	R/W
19	Unused	W	R/W
20	Unused	X	AUD TEST
21	+5V	Y	$\overline{Ø2}$
22	GND	Z	Ram-R/W

(1) Jumper option

APPLICATION (A)

1	GND	A	+5V
2	APA3	B	$\overline{00}$
3	APA2	C	$\overline{04}$
4	APA1	D	$\overline{08}$
5	APA4	E	$\overline{0C}$
6	APA5	F	$\overline{10}$
7	APA6	H	$\overline{14}$
8	APA7	J	$\overline{1C}$
9	APB0	K	$\overline{18}$
10	APB1	L	Audio In
11	APB2	M	Audio Out (LO)
12	APB3	N	RCN-1 (1)
13	APB4	P	Audio Out (HI)
14	APA0	R	TTY KB RTN (+)
15	APB7	S	TTY PTR (+)
16	APB5	T	TTY KYRD
17	KB ROW O	U	TTY PTR
18	KB COL F	V	KB ROW 3
19	KB COL B	W	KB COL G
20	KB COL E	X	KB ROW 2
21	KB COL A	Y	KB COL C
22	KB COL D	Z	KB ROW 1

AUXILIARY APPLICATION (AA)

1	GND A	+5V	
2	-VN B	+VP	
3	2 PA 1	C	2 PA 2
4	2 CA 2	D	2 PA 0
5	2 EB 2	E	2 CA 1
6	2 PB 7	F	2 CA 2
7	2 PB 5	H	2 PB 6
8	2 PB 3	J	2 PB 4
9	2 PB 1	K	2 PB 2
10	2 PA 7	L	2 PB 0
11	2 PA 5	M	2 PA 6
12	2 PA 3	N	2 PA 4
13	RES	P	3 CA 1
14	3 CB 1	R	SCOPE
15	3 PB 2	S	3 PB 3
16	3 PB 0	T	3 PB 1
17	3 PA 6	U	3 PA 7
18	3 PA 3	V	3 PA 0
19	3 PA 4	W	3 PA 1
20	3 PA 5	X	3 PA 2
21	3 PB 5	Y	3 PB 4 (B)
22	3 PB 7	Z	3 PB 6 (B)
23		AUD OUT LO	
24		-	
25		AUD GND	

Table 4-2. CONNECTOR POINTS AND THEIR FUNCTIONS IN VIM-1

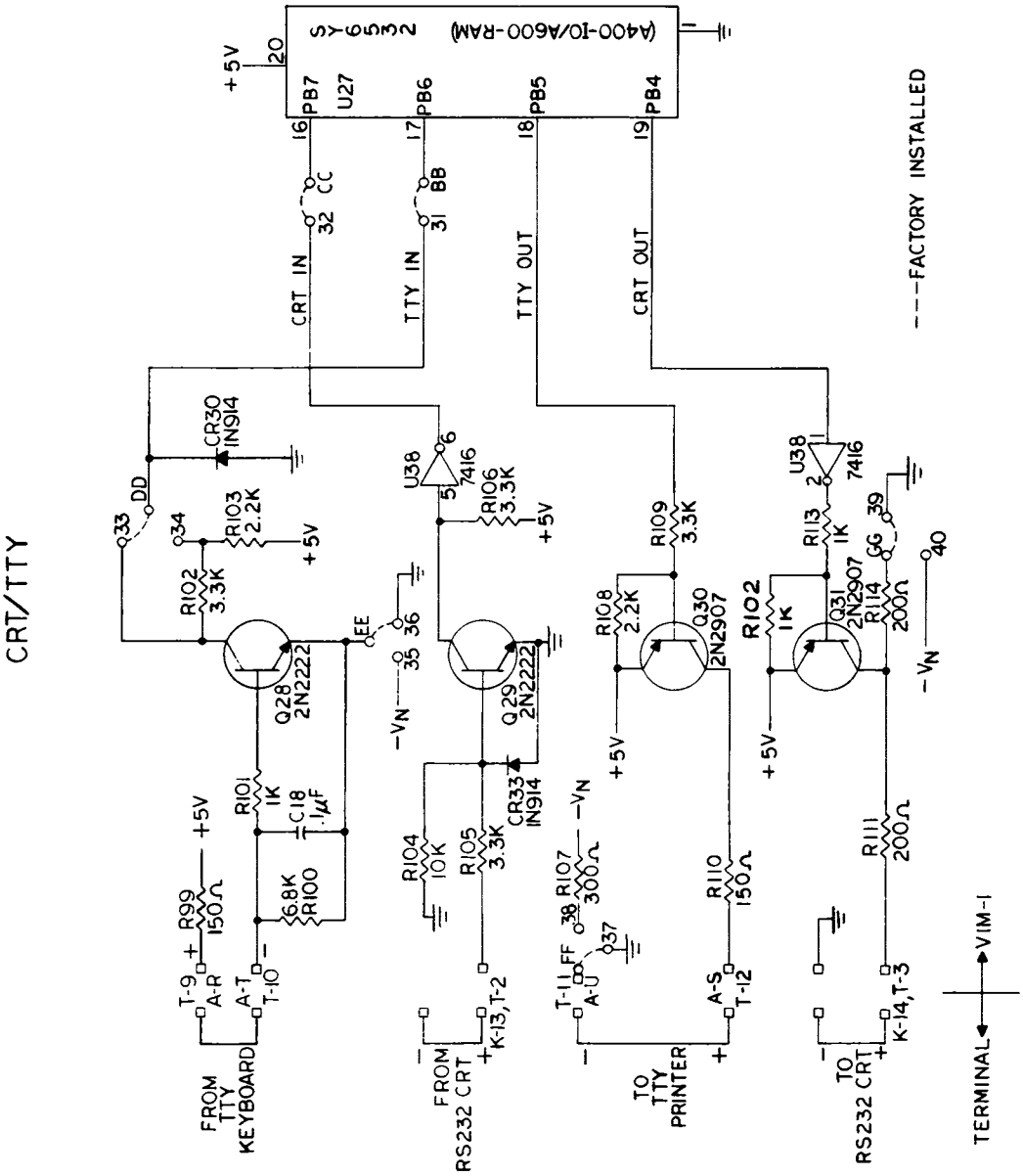


Figure 4-2. TTY/CRT INTERFACE SCHEMATIC

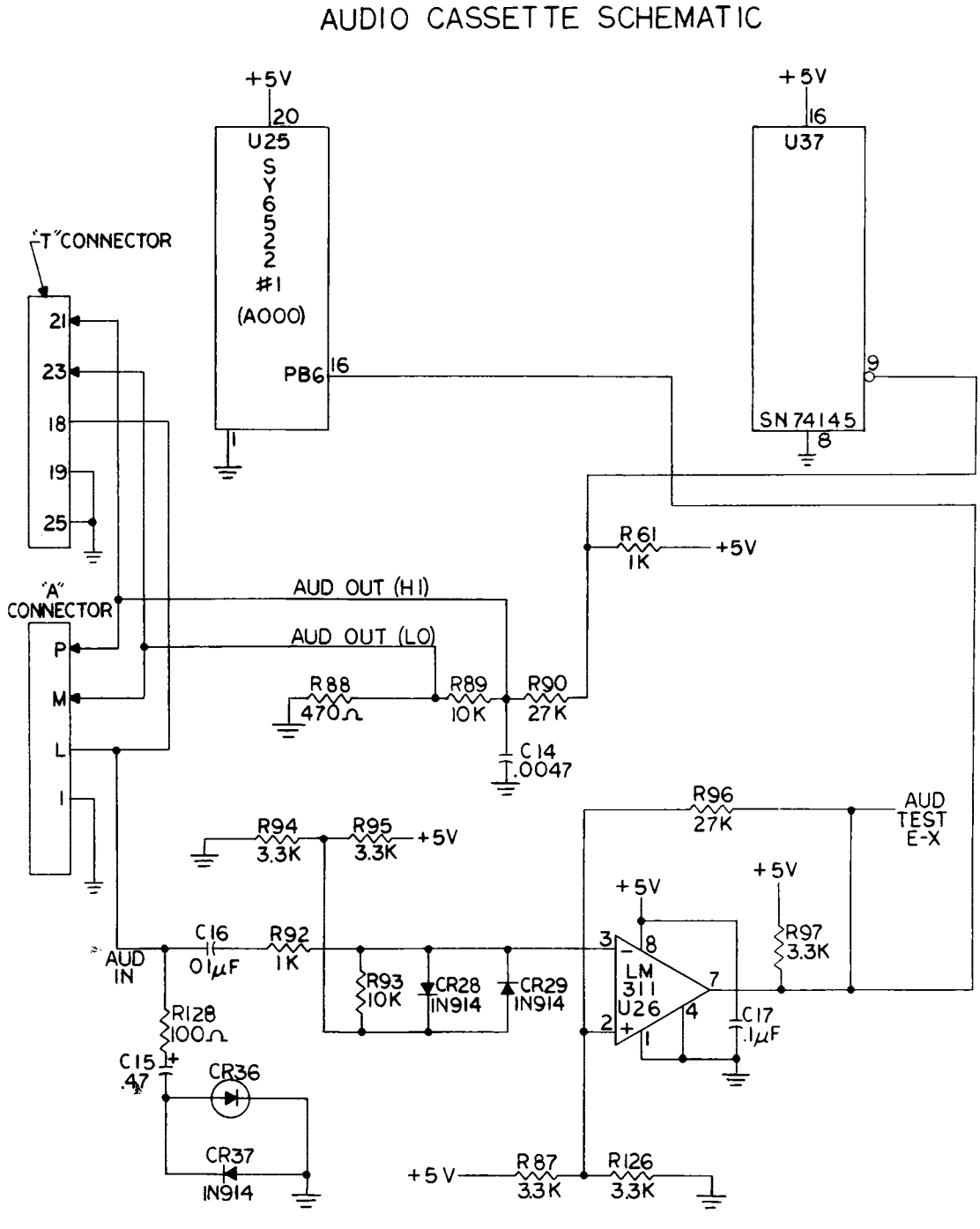


Figure 4-3. AUDIO CASSETTE INTERFACE SCHEMATIC

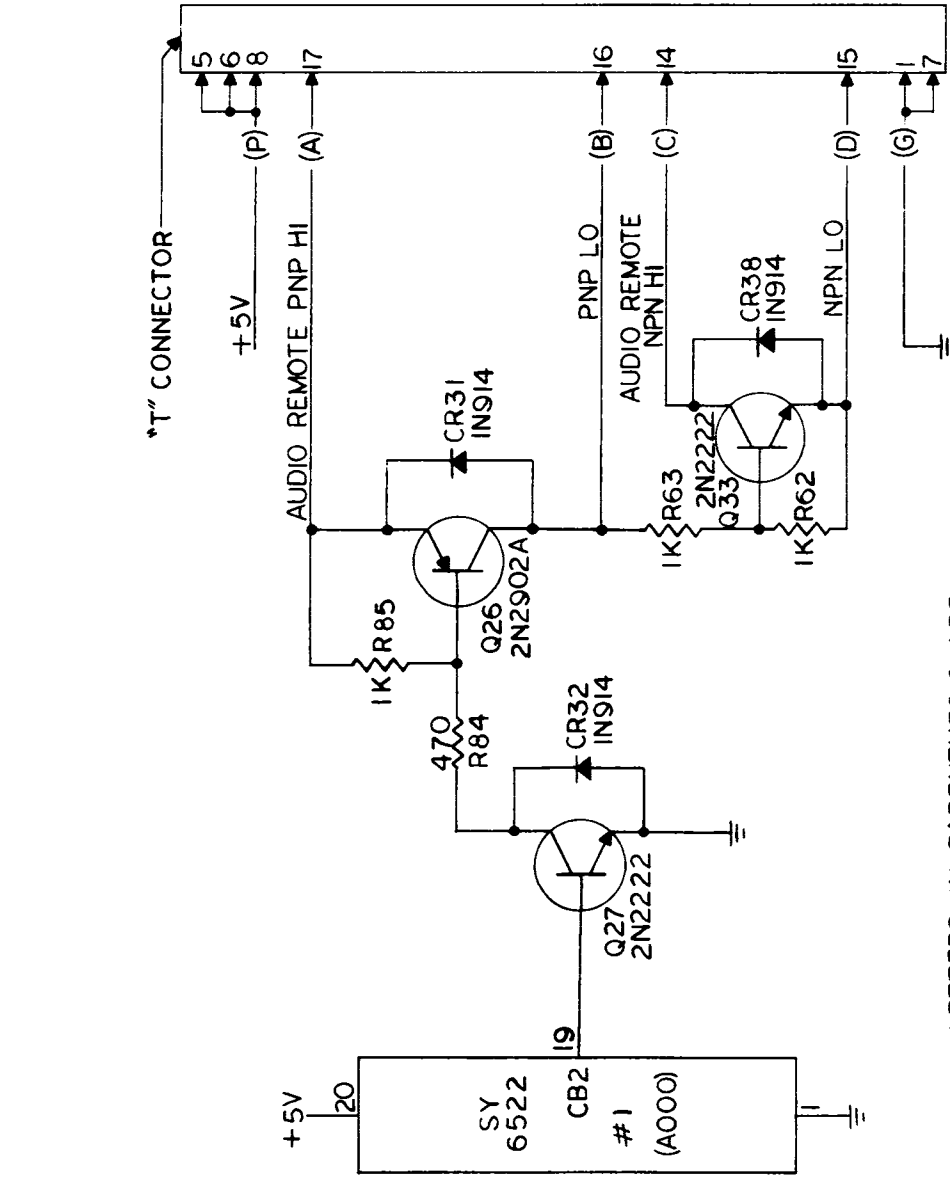
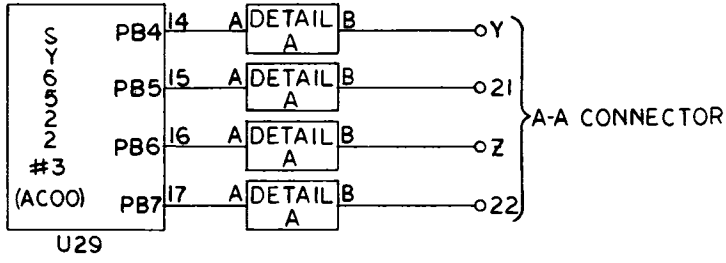


Figure 4-4. AUDIO CASSETTE REMOTE CONTROL

I/O BUFFERS



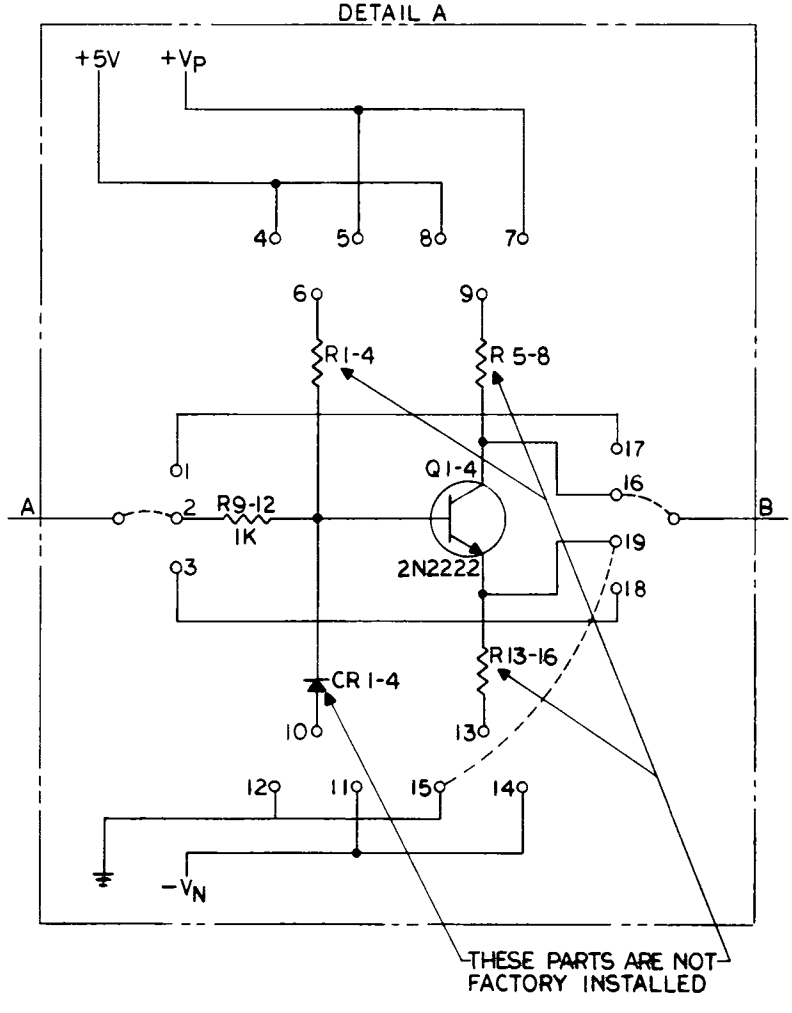


Figure 4-5. I/O BUFFERS SCHEMATIC

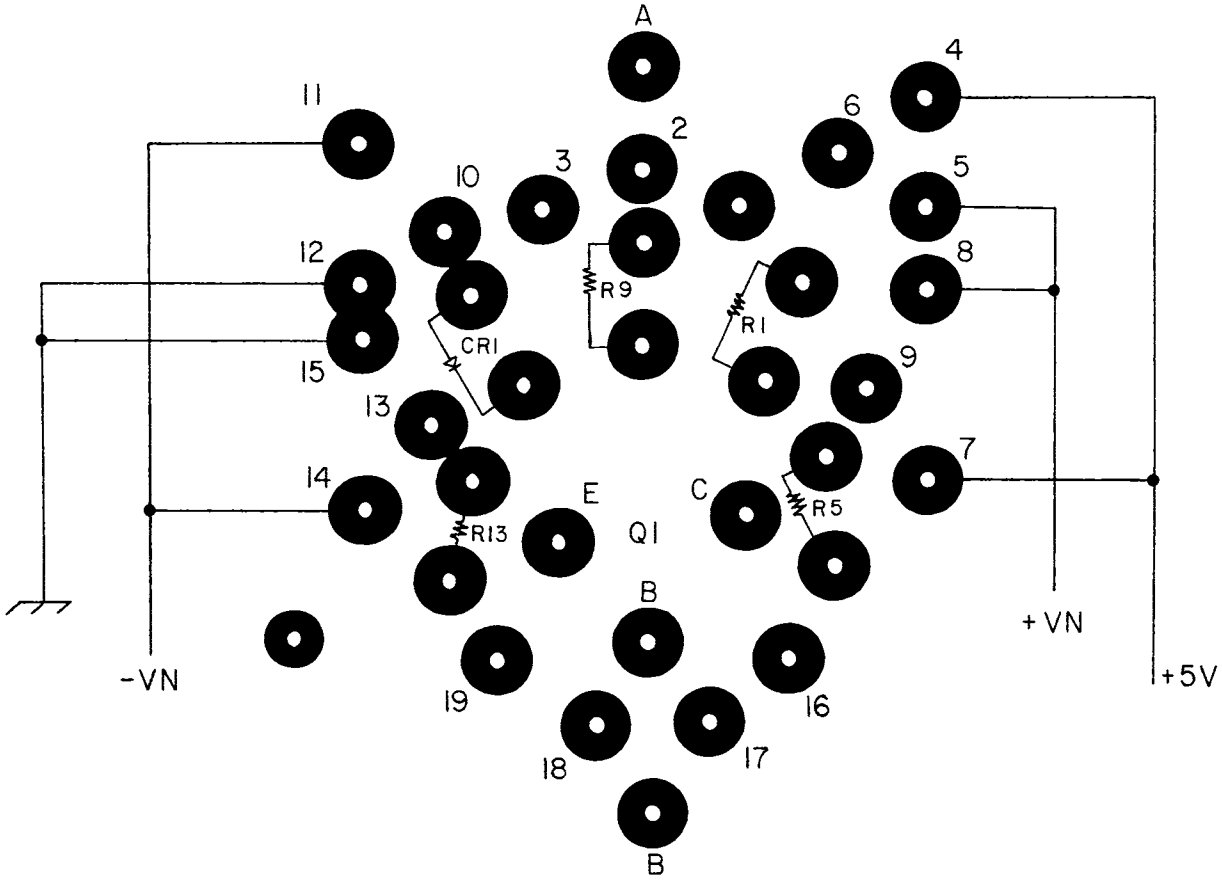


Figure 4-5a. I/O BUFFERS, PC SEGMENT BLOW-UP

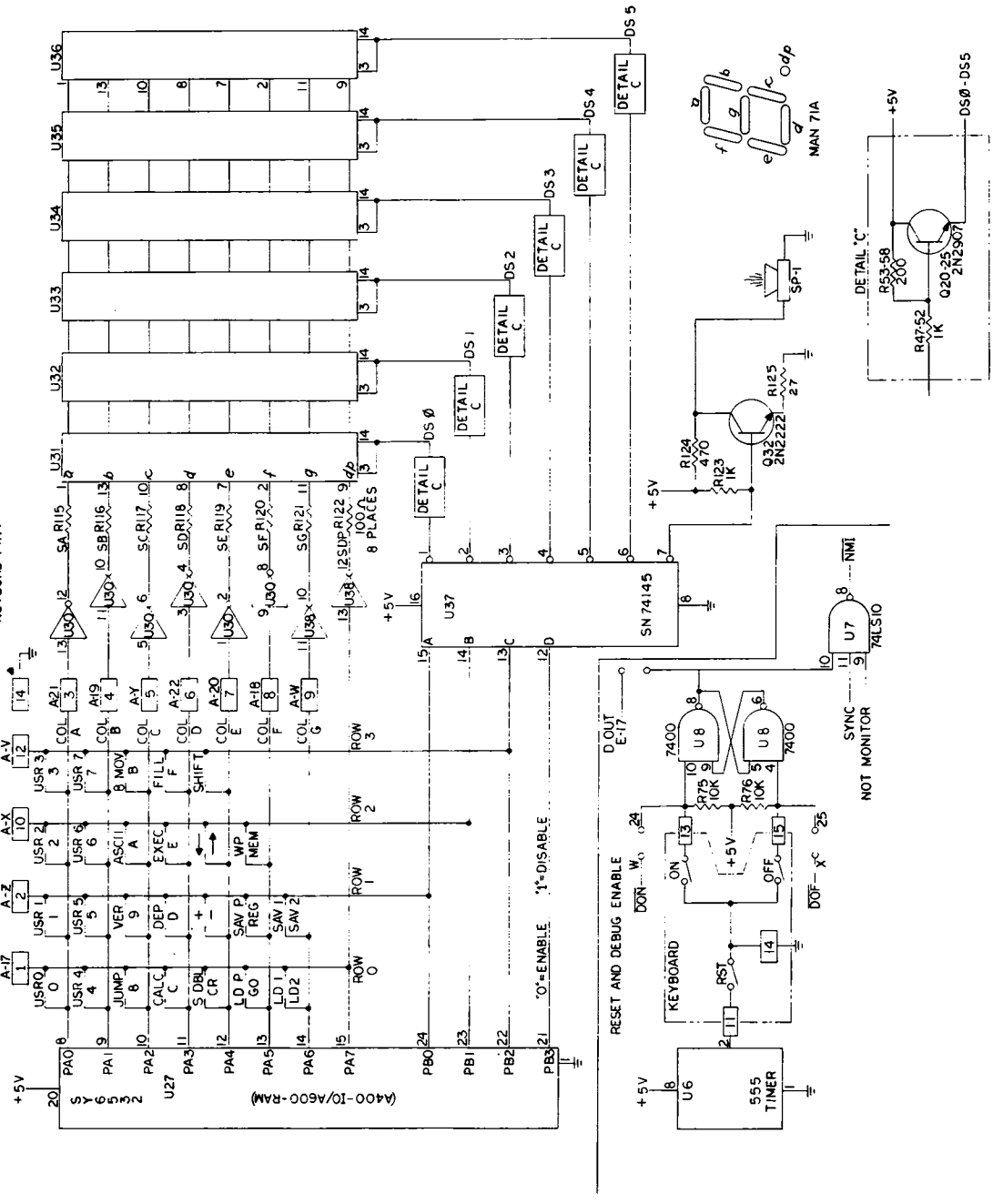


Figure 4-6. KEYBOARD/DISPLAY SCHEMATIC

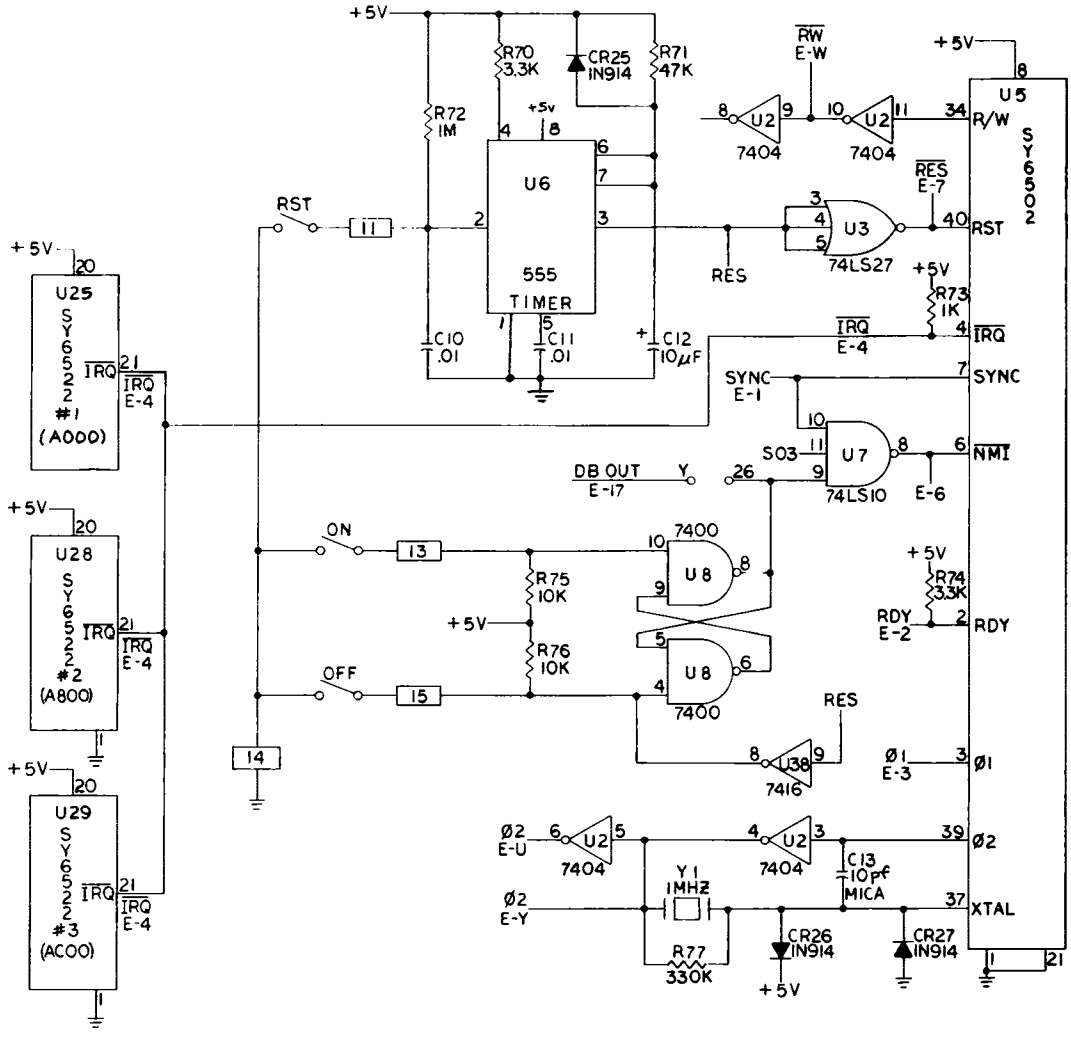


Figure 4-7. CONTROL SECTION SCHEMATIC

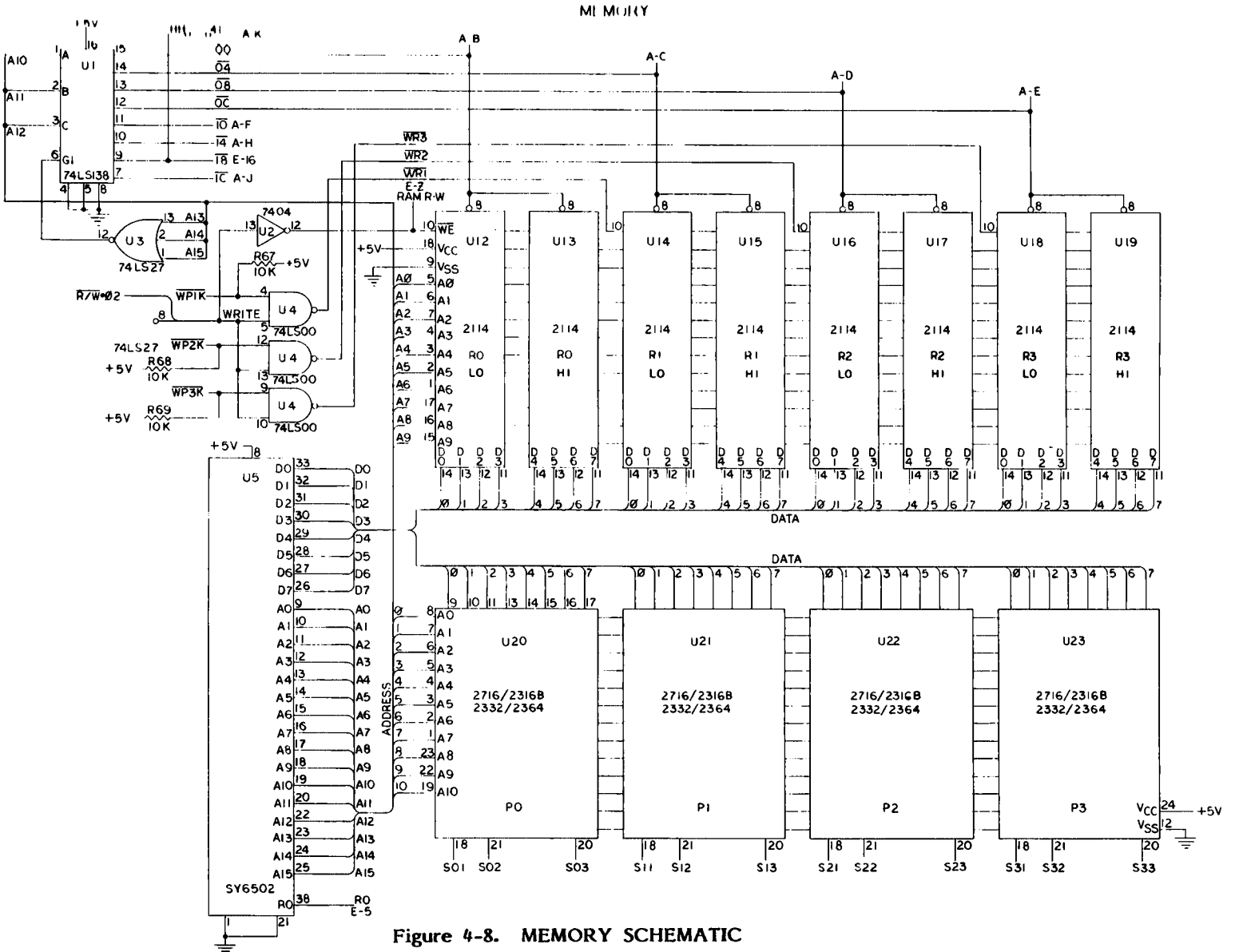


Figure 4-8. MEMORY SCHEMATIC

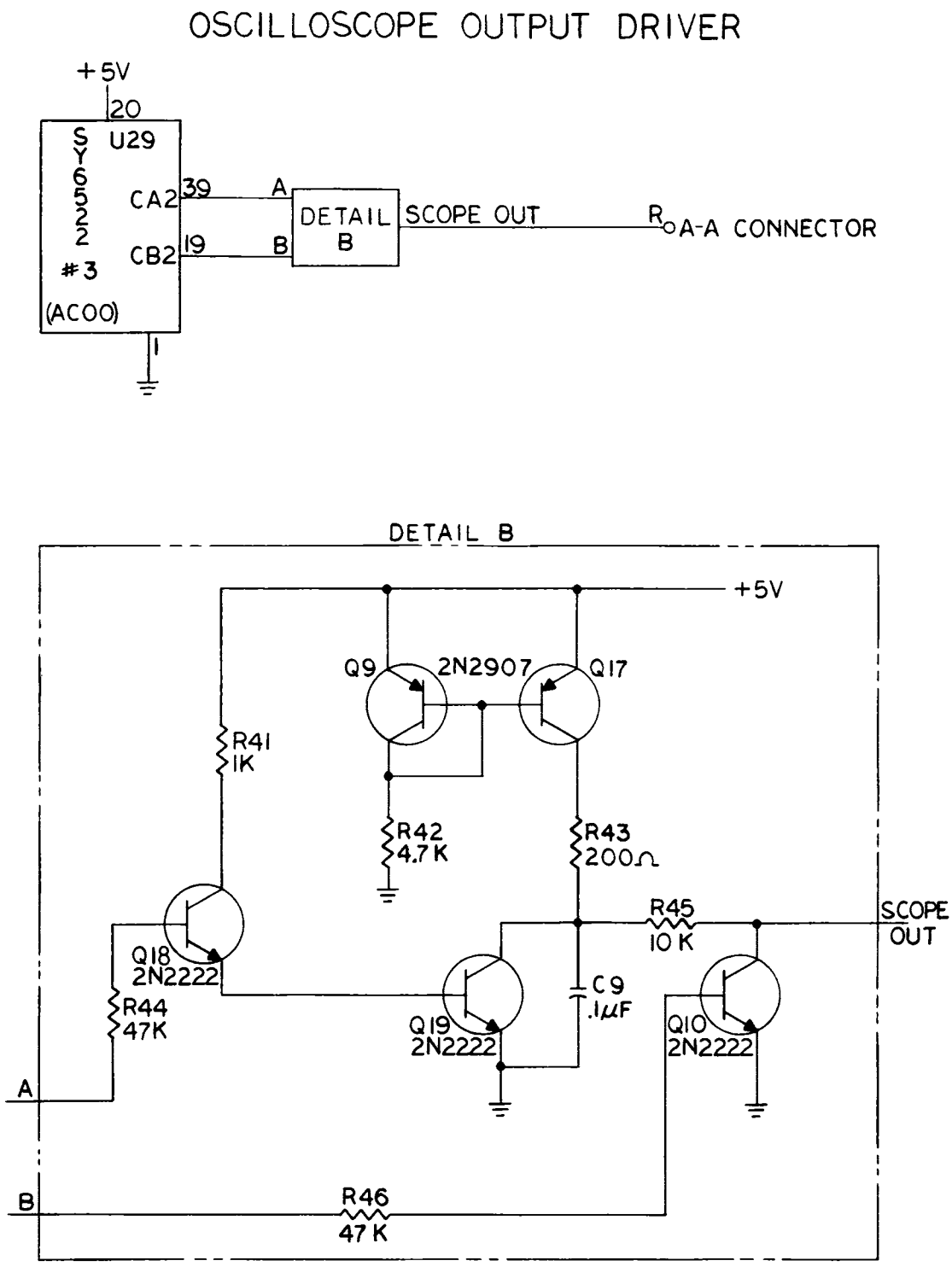


Figure 4-9. OSCILLOSCOPE OUTPUT DRIVER SCHEMATIC

4.2 MEMORY ALLOCATION

This section describes the standard memory allocation in your VIM-1 microcomputer system. It makes extensive use of the detailed Memory Map contained in Figure 4-10. Also described in this section is the technique by which ROM and RAM addressing and usage may be altered by using an array of on-board jumpers which allow you to modify and expand your VIM-1 memory. Expanding RAM memory using off-board components is taken up briefly in Section 4.2.3, although a detailed discussion of this is reserved for Chapter 8, "System Expansion".

4.2.1 Standard Memory Allocation

Figure 4-10 is a map of the standard memory allocation in your VIM-1 microcomputer. Provided with your system are 1K of on-board RAM, extending from location 0000 to 03FF in the Memory Map. Note that the top-most eight bytes (locations 00F8 to 00FF) in Page Zero of this 1K block are reserved for use by the system and should not be used by your programs. The remainder of Page Zero is largely similar to the rest of the RAM provided, but it also has some special significance for addressing which will become clearer in Section 4.3. Locations 0100-01FF in the 1K memory block furnished with your system are reserved for stack usage. Your programs may use this area, but you should use it for normal stack operations incidental to operating your programs. Locations 01FF-03FF are general-use RAM for your program and data storage.

In addition to the 1K of on-board RAM furnished with your system, sockets are provided for 3K of plug-in RAM, allowing you to have 4K of on-board RAM memory. These sockets occupy memory locations 0400-0FFF.

The SUPERMON monitor resides in ROM at memory locations 8000-8FFF. (As you know, the SY6502 CPU addresses all memory and I/O identically, so that it is immaterial whether a specific address location is occupied by RAM, ROM or I/O devices.) The next 4K block, from 9000-9FFF, is reserved for future expasion of SUPERMON, although you may use those locations if you wish to do so, provided you remember that if you should obtain an expanded SUPERMON system in the future these addresses may be used.

Extending from A000-AFFF are the I/O devices on your VIM-1 module. As we have previously said, each port on the SY6522/SY6532 devices in VIM-1 is an addressable location. Sheets 2-6 of Figure 4-10 provide you with a detailed Memory Map breakdown of how these devices are addressed. Note that within the SY6532 is a 128 byte segment (locations A600-A7FF). This is the RAM which is resident on the SY6532 used by VIM-1 as System RAM. Sheet 4 of Figure 4-10 describes each memory location within System RAM in detail; you will need this data if you wish to make use of the capability of the system for modifications to SUPERMON. These modifications may include creating your own commands (as described in Chapter 5) which may be entered as if they were Monitor commands. Other such modifications making use of System RAM locations are described in Chapter 9 of this manual.

Memory locations B000-FF80 may be used by your programs, provided of course you have expanded memory to fill those address locations (see Chapter 8). Note, however, that if you plan to obtain the Synertek Systems 8K BASIC module at some later date, that module will occupy locations C000-DFFF. You should plan your applications programs accordingly. Locations FF80-FFFF are reserved for special use by the system, and should not be used in any of your applications code.

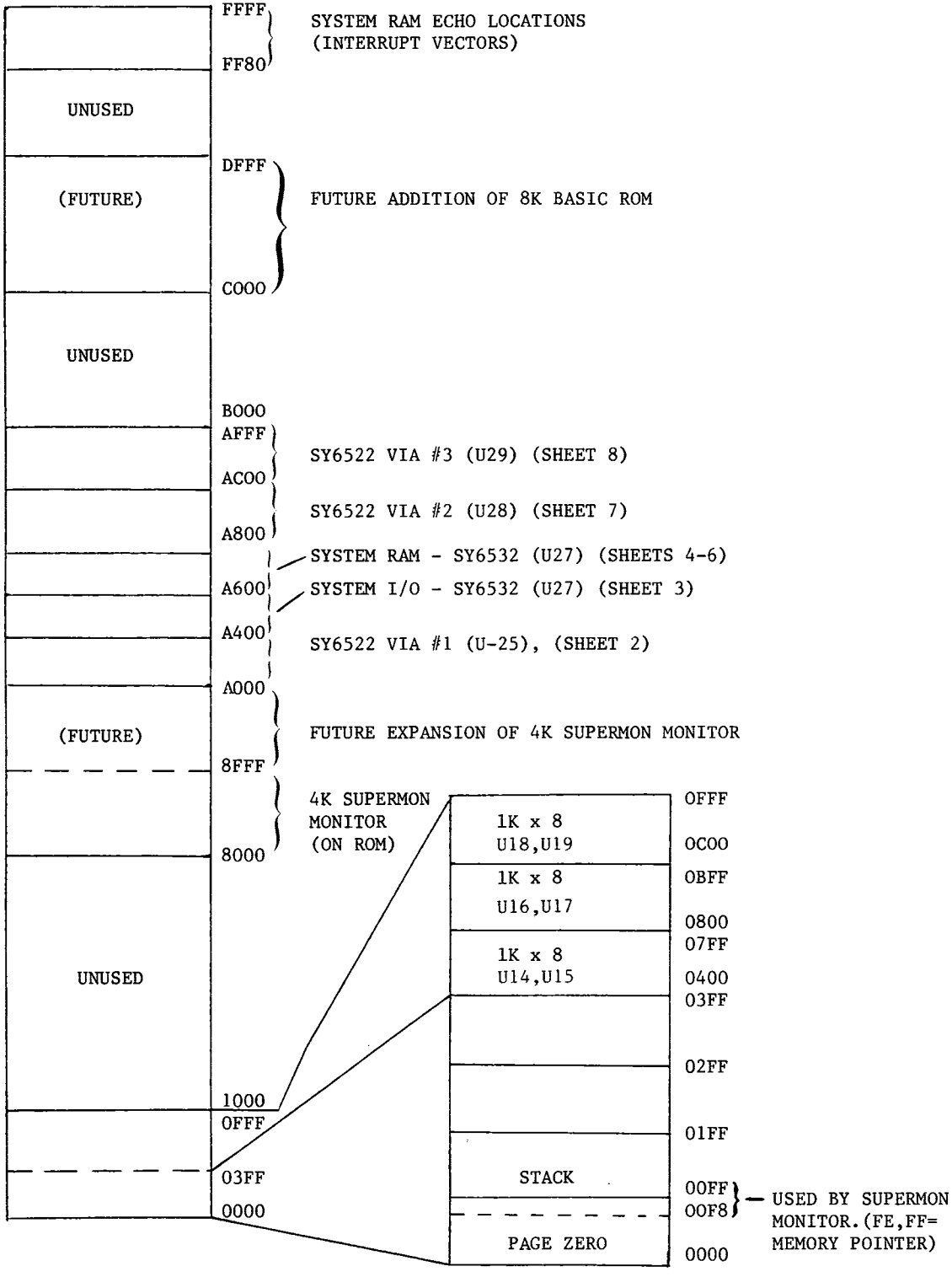


FIGURE 4-10. STANDARD MEMORY MAP, VIM-1

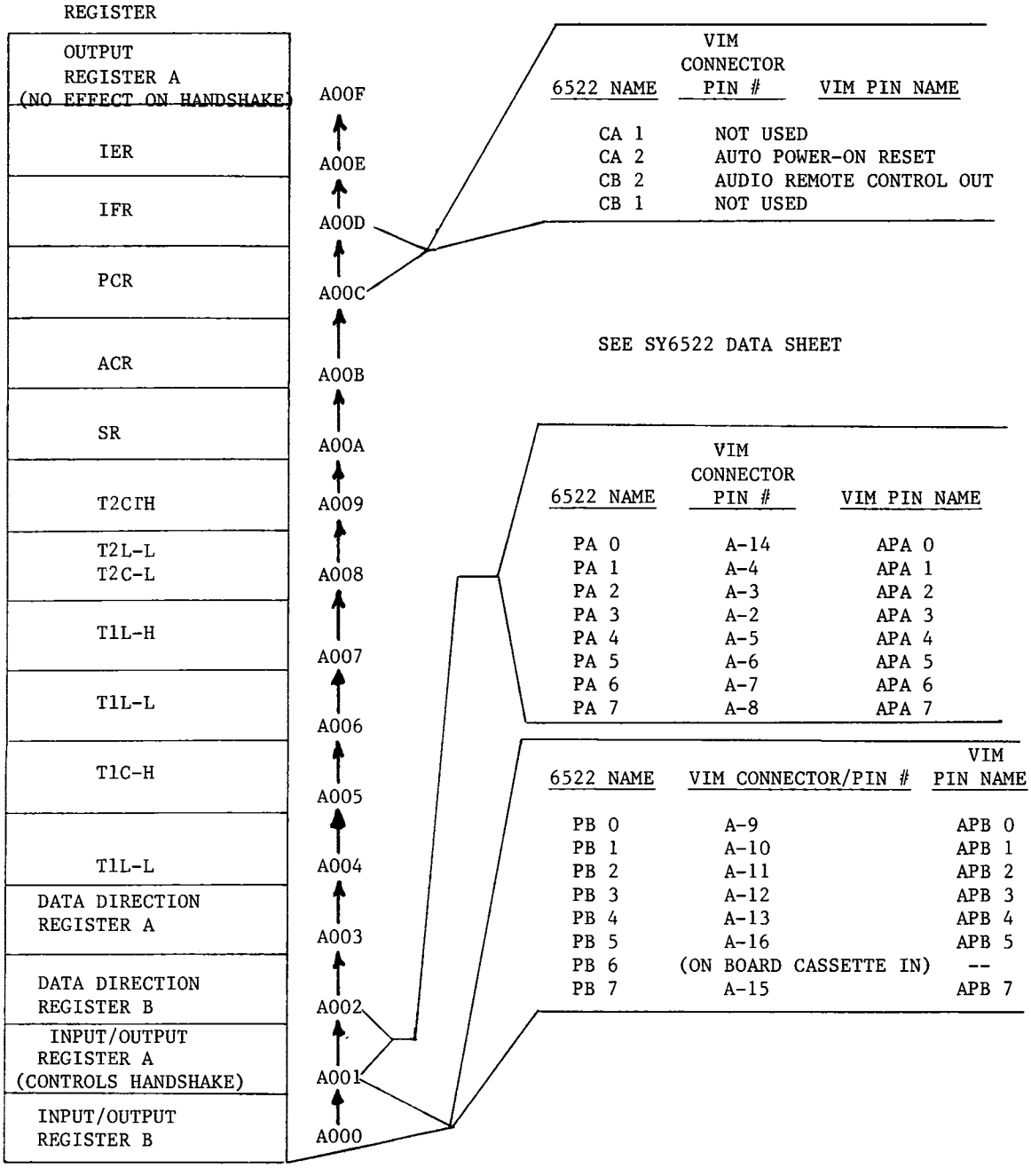


FIGURE 4-10 (CONT'D). MEMORY MAP FOR SY6522 VIA #1 (DEVICE U25)

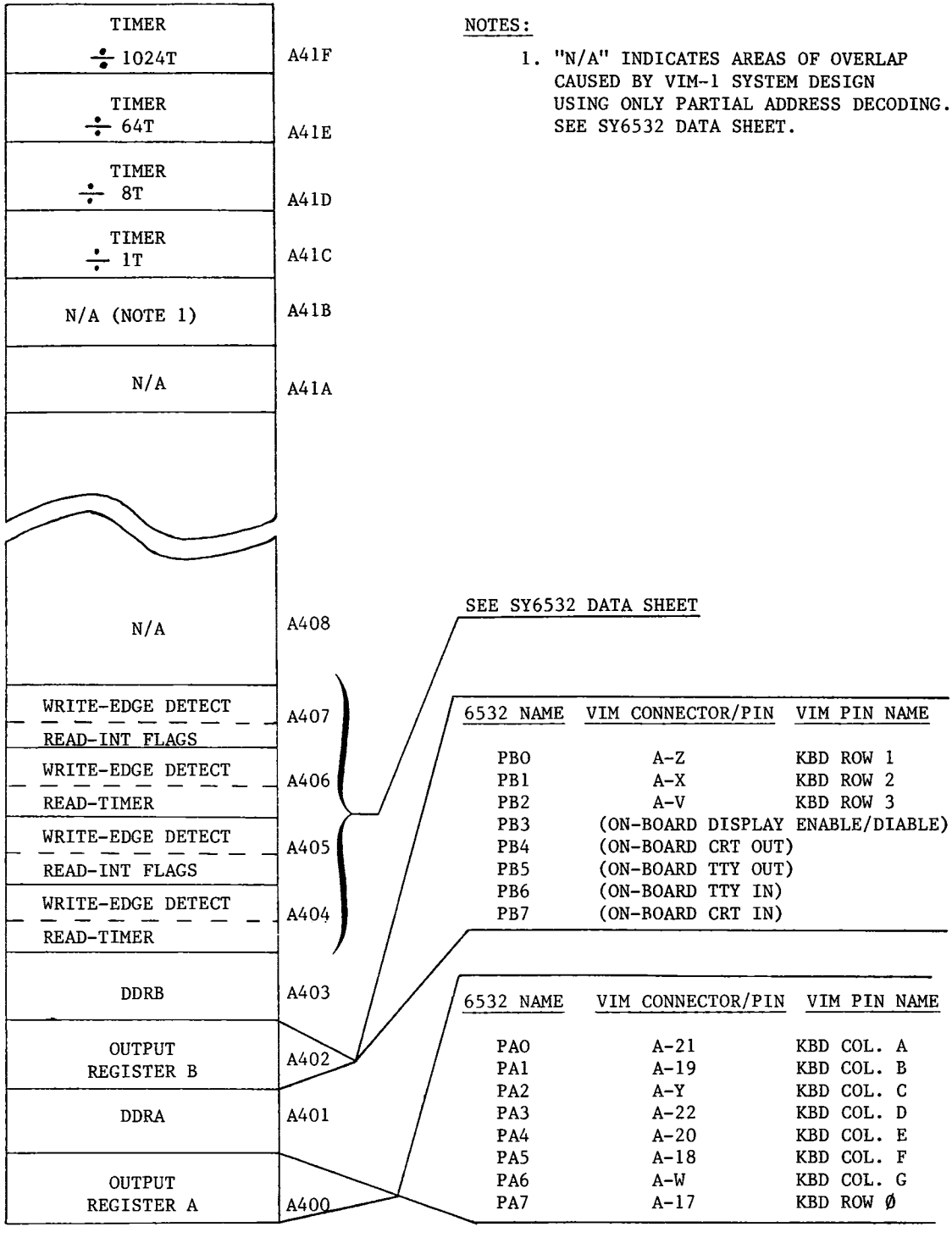


FIGURE 4-10 (CONT'D). MEMORY MAP FOR SY6532(DEVICE U27)

SYMBOL	ADDRESS	DEFAULT VALUE	COMMENTS
IRQVEC	A67F	80	IRQ Vector
	A67E	0F	
RSTVEC	A67D	8B	RESET Vector
	A67C	4A	
NMIVEC	A67B	80	NMI Vector
	A67A	9B	
UIRQVC	A679	80	User IRQ Vector
	A678	29	
UBRKVC	A677	80	User Break Vector
	A676	4A	
TRCVEC	A675	80	Trace Vector
	A674	C0	
EXEVEC	A673	88	'Execute' Vector
	A672	7E	
SCNVEC	A671	89	
	A670	06	Display Scan Vector
	A66F	4C	
URCVEC	A66E	81	
	A66D	D1	Unrecognized Command Vector
	A66C	4C	
	A66B	00	
	A66A	00	Not Used
	A669	00	
INSVEC	A668	89	
	A667	6A	In Status Vector
	A666	4C	
OUTVEC	A665	89	
	A664	00	Output Vector
	A663	4C	
INVEC	A662	89	
	A661	BE	Input Vector
	A660	4C	
YR	A65F	00	
XR	A65E	00	
AR	A65D	00	
FR	A65C	00	User Registers
SR	A65B	FF	
PCHR	A65A	8B	
PCLR	A659	4A	
MAXRC	A658	10	Max. No. Bytes/Record, Paper Tape (Note 6)
LSTCOM	A657	00	Last Monitor Command
TV	A656	00	Trace Velocity (Note 5)
KSHFL	A655	00	Hex Keyboard Shift Flag
TOUTFL	A654	B0	In/Out Enable Flags (Note 4)

Figure 4-10. SYSTEM RAM MEMORY MAP, SY6532

SYMBOL	ADDRESS	DEFAULT VALUE	COMMENTS
TECHO	A653	80	Terminal Echo (Note 3)
ERCNT	A652	00	Error Count (Note 2)
SDBYT	A651	4C	Baud Rate (Note 1)
PADBIT	A650	01	Number of Padbits on Carriage Return
P1H	A64F	00	
P1L	A64E	00	
P2H	A64D	00	16-Bit Parameters
P2L	A64C	00	
P3H	A64B	00	
P3L	A64A	00	
PARNR	A649	00	No. of Parameters Entered
	A648	00	
	A647	00	Not Used
	A646	00	
RDIG	A645	3F	Right-most Digit
DISBUF	A644	86	
	A643	6E	
	A642	6D	Display Buffer
	A641	00	
	A640	00	
SCRF	A63F	00	
			Monitor Scratch Locations SCR0-SCRF
SCR0	A630	00	
JTABLE	A62F	D0	User Socket P3 (Jump Entry No. 7)
	A62E	00	
	A62D	C8	User Socket P2 (Jump Entry No. 6)
	A62C	00	
	A62B	03	0300 (Jump Entry 5)
	A62A	00	
	A629	02	0200 (Jump Entry 4)
	A628	00	
	A627	00	0000 (Jump Entry 3)
	A626	00	
	A625	8B	NEWDEV (Jump Entry 2)
	A624	64	
	A623	8B	TTY (Jump Entry 1)
	A622	A7	
	A621	C0	BASIC (Jump Entry 0)
	A620	00	
SCPBUF	A61F	--	
			Scope Buffer, No Defaults (32 locations)
	A600	--	

Figure 4-10. SYSTEM RAM MEMORY MAP, SY6532 (Continued)

NOTES - SYSTEM RAM

1. BAUD RATE -

BAUD	SDBYT
110	D5
300	4C
600	24
1200	10
2400	06
4800	01

2. ERCNT - Used by LD P, FILL, B MOV

   Count of bytes which failed to write correctly
   And invalid checksums up to $FF

3. TECHO - bit 7 - ECHO/NO ECHO

   bit 6 - OUTPUT/NO OUTPUT This bit is toggled everytime a control O (ASCII 0F) is encountered in the input stream.

4. TOUTFL - bit 7 = enable CRT IN
   bit 6 = enable TTY IN
   bit 5 = enable TTY OUT
   bit 4 = enable CRT OUT

5. TV - TRACE VELOCITY
   00 = SINGLE STEP

   non-zero - PRINT PC, A
   THEN PAUSE AND RESUME

   PAUSE DEPENDS ON TV
   (TRY TV = 09)

6. USER PC - DEFAULT = 8B4A = RESET

Figure 4-10. SYSTEM RAM MEMORY MAP, SY6532 (Continued)

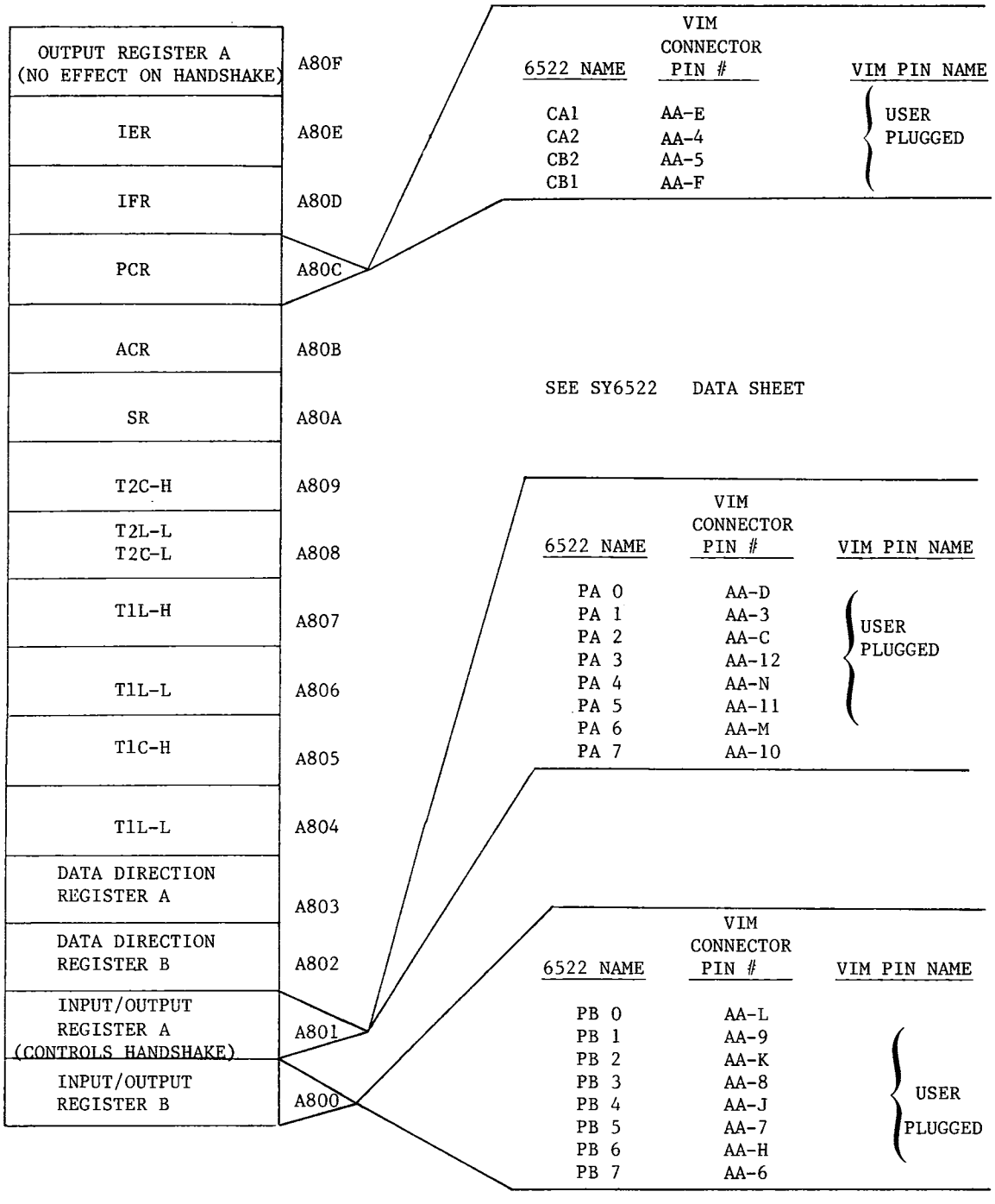


FIGURE 4-10 (CONT'D). MEMORY MAP FOR SY6532 VIA #2 (DEVICE U28)

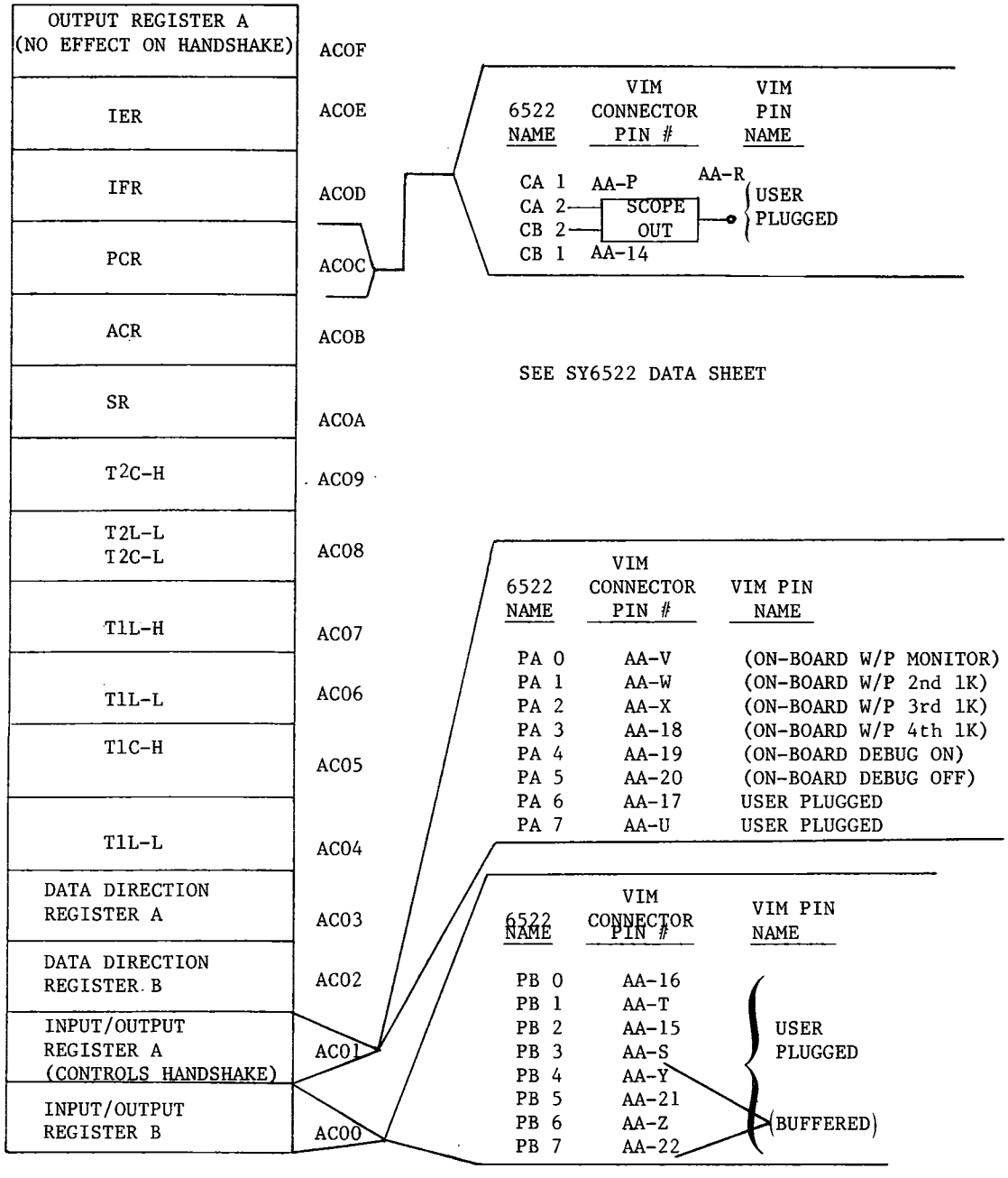


FIGURE 4-10 (CONT'D). MEMORY MAP FOR SY6522 VIA #3 (DEVICE U29)

4.2.2 Address Decoding Jumper Options

Four sockets (labeled P0-P3 on the board) for ROM PROM or EPROM are provided with your VIM-1. Each socket may contain any of four different types of Read-Only Memory devices, up to a total of 24K. The four acceptable devices are the SY2716, the SY2316B, the SY2332 and the SY2364. Each device is slightly different, but they are all read-only memories. They may appear in any combination on a VIM-1 microcomputer system, provided their total capacity does not exceed 24K. But since the devices have different memory capacities, it is necessary to alter normal addressing to accomodate the specific devices selected.

To serve this purpose, we have provided a set of jumpers, located just to the left of the center of the board and directly under the two 74LS145's. The schematic in Figure 4-11 illustrates each useful jumper combination and Table 4-3 outlines them in greater detail. (Note that Table 4-3 contains other jumpers available on the VIM-1, not all of which pertain to memory use.) The broken lines in Figure 4-11 indicate the jumpers installed at the factory. Note, for example, that the first PROM socket, labeled PO (device U20) is associated with the address group beginning with 8000. It it were necessary to change this configuration, you would remove the connection from Pin 1 of the lower address decoder (74LS145) to jumper connection 7-J so that it becomes associated with a jumper combination which addresses the device you wish to address. Table 4-3a will assist you in configuring your selection of ROM correctly.

Near the bottom of the board below the speaker unit are four jumpers labeled JJ, KK, LL and MM. These enable Write Protection on the RAM in the four 1K blocks available on the board. Jumper 45-MM is factory-installed, enabling Write Protection on System RAM (the 128-byte block in the SY6532). As you add RAM later, or to Write Protect any of the on-board RAM aside from System RAM, you must connect the appropriate jumpers to enable the Write Protect function on the desired memory locations. RAM may be enabled for Write Protect in 1K blocks.

These jumpers offer you flexibility to adapt the VIM-1 board to your particular application. The jumpers will give you the ability to do the following:

- Use 2K, 4K, or 8K byte ROM or PROM in each 24 pin socket.
- Complete flexibility in selecting user PROM addressing.
- Ability to auto power-on to any of the ROM/PROM sockets.
- Write protect expansion RAM.

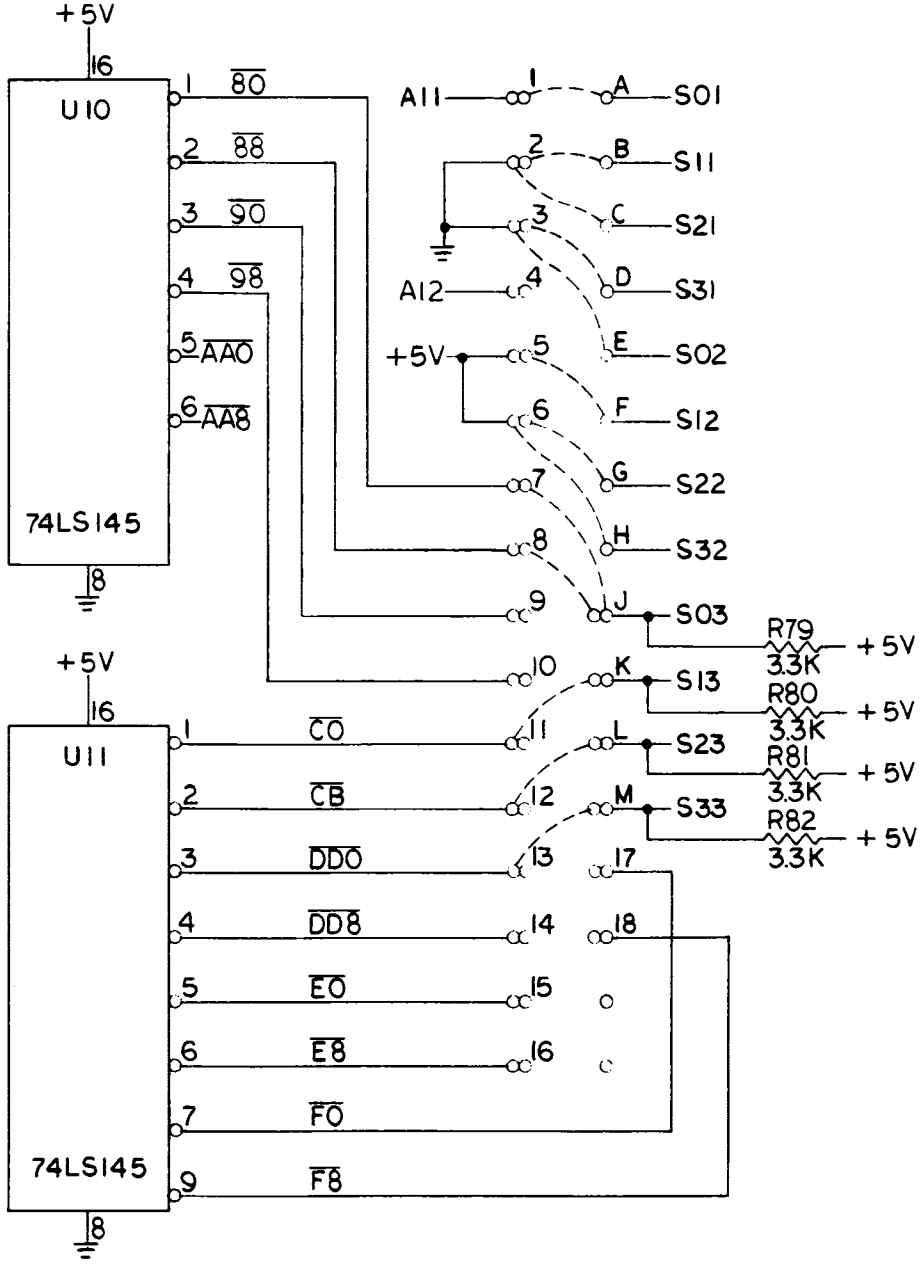
4.2.3 Off-Board Expandability

VIM-1 is expandable, on-board, up to 24K bytes of program memory and 4K bytes of RAM, with 8K bytes of address space allocated to the on-board I/O devices. Further expansion of any combination of ROM, PROM, RAM or I/O can be implemented by using VIM's "E" (Expansion) connector to attach an auxiliary board containing the additional devices. Total expandability is limited only by the amount of addressing capability of the SY6502 CPU, i.e., 64K bytes.

Detailed instructions for implementing off-board expansion are contained in Chapter 8, "System Expansion."

4.2.4 I/O Buffers

Your VIM-1 board comes to you equipped with four specially configured I/O buffer circuits. (See Figure 4-5.) The circuit configuration and PC Board layout allow the user to configure these bufers in many ways.



----CONFIGURATION OF DELIVERED VERSION

Figure 4-11. MEMORY ADDRESS DECODING JUMPER OPTIONS

Table 4-3. VIM-1 JUMPERS

JUMPER LETTER	POSITION NUMBER	DESCRIPTION
A,B,C,D E,F,G,H	1,2,3 4,5,6	PROM/ROM Device Select (See Table 4-3a)
J,K,L,M	7,8,9,10,11,12 13,14,15,16,17,18	ADDRESS SELECT (See Table 4-3b)
N	19 (1) 20	Auto Power-On to U20 (2) Disable Auto Power-On to U20
P	19 (1) 20	Auto Power-On to U21 (2) Disable Auto Power-On to U21
R	19 (1) 20	Auto Power-On to U22 (2) Disable Auto Power-On to U22
S	19 (1) 20	Auto Power-On to U23 (2) Disable Auto Power-On to U23
T	21	Enables Monitor RAM at A0xx (3)
U	22	Enables Monitor RAM at F8xx (3)
V	23	RCN-1 to connector A-N
W	24	Enables Software Debug ON
X	25	Enables Software Debug OFF
Y	26	DBOUT to connecector E-17
BB	31	Connects TTY IN to PB6 @A402
CC	32	Connects CRT IN to PB7 @A402
DD	33 34	To run TTY @ +5V and GND To run TTY @ +5V and -Vn (4)
EE	35 36	To run TTY @ +5V and GND To run TTY @ +5V and -Vn (4)
FF	37 38	To run TTY @ +5V and GND To run TTY @ +5V and -Vn (4)
GG	39 40	To run RS232 @+5V and GND To run RS232 @+5V and -Vn (5)
HH	41	Decode line $\overline{18}$ to connector A-K
JJ	42	Enable software write protect 3K block
KK	43	Enable software write protect 2K block
LL	44	Enable software write protect 1K block
MM	45	Enable software write protect monitor RAM

Table 4-3. VIM-1 JUMPERS (Continued)

NOTES

1 Only one socket (U20, U21, U22, U23) should be jumpered to position 19 at one time. The remaining three sockets should be jumpered to position 20.

2 See software consideration of auto power-on in Chapter 9.

3 One or both can be connected at the same time.

4 These positions require a recommended -9V to -15V supply applied to the power connector pin E. R107 should be adjusted (removed and replaced) for your proper current loop requirements.

Example: (for 60ma current loops and Vn = -10V)

a. Connect DD to 33
EE to 35
FF to 38

b. $R107 = \frac{Vn - 5V}{I} = \frac{(10 - 5)}{60\ ma} \cong 100\,\Omega$

R107 = 300Ω (as installed) for 20 ma current loop and Vn=-10V

5 For RS232 devices using other than LM1489 or equivalent input receivers (i.e., probably terminals older than ten years) then GG should be strapped to 40 and a -9V to -15V supply applied to the power connector pin E.

Table 4-3a. VIM-1 PROM/ROM DEVICE SELECT

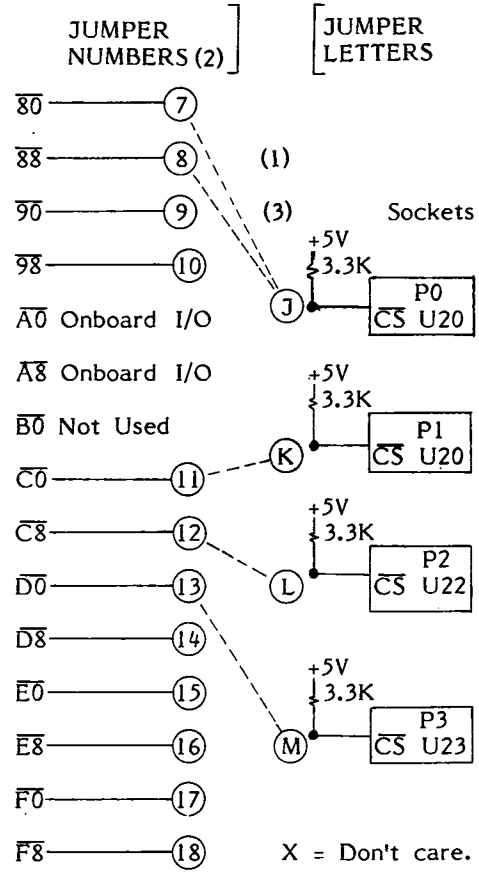
SOCKET LOCATION	SOCKET NAME	MEMORY DEVICE	JUMPER LETTER	POSITION NUMBER
U20	P0	2716	A E	2 or 3 5 or 6
U20	PO	2316	A E	2 or 3 2 or 3
U20	PO	2332	A E	1 2 or 3
U20	PO	2364	A E	1 4
U21	P1	2716	B F	2 or 3 5 or 6
U21	P1	2316	B F	2 or 3 2 or 3
U21	P1	2332	B F	1 2 or 3
U21	P1	2364	B F	1 4
U22	P2	2716	C G	2 or 3 5 or 6
U22	P2	2316	C G	2 or 3 5 or 6
U22	P2	2332	C G	1 2 or 3
U22	P2	2364	C G	1 4
U23	P3	2716	D H	2 or 3 5 or 6
U23	P3	2316	D H	2 or 3 2 or 3
U23	P3	2332	D H	1 2 or 3
U23	P3	2364	D H	1 4

NOTE: 2716 devices assumes Synertek, Intel or equivalent pin outs.

Table 4-3b. VIM-1 ADDRESS SELECT

High Order VIM-1 Address lines

2K Blocks	A 15	A 14	A 13	A 12	A 11	A 10	A 9	A 8
	1	0	0	0	0	X	X	X
	1	0	0	0	1	X	X	X
	1	0	0	1	0	X	X	X
	1	0	0	1	1	X	X	X
	1	0	1	0	0	X	X	X
	1	0	1	0	1	X	X	X
	1	0	1	1	0	X	X	X
	1	1	0	0	0	X	X	X
	1	1	0	0	1	X	X	X
	1	1	0	1	0	X	X	X
	1	1	0	1	1	X	X	X
	1	1	1	0	0	X	X	X
	1	1	1	0	1	X	X	X
	1	1	1	1	0	X	X	X
	1	1	1	1	1	X	X	X



NOTES:
(1) Broken lines indicate delivered version of jumpers.
(2) Each jumper number represents a 2K address space decode.
(3) Jumper numbers can be wire or'ed to increase the address space of the $\overline{CS}$ on any socket (i.e., decoder is open collector.)

The single-stage circuit consists of a transistor and "circuit positions" for the user to add resistors, capacitors and dioders in any of many positions. This flexibility allows inverting and noninverting stages, input-resistive or capacitive coupling and much more. The user should refer to the schematic and P.C. layout in Figure 4-5a in order to completely understand this circuit.

4.3 SOFTWARE DESCRIPTION

Software on your VIM-1 microcomputer must be discussed from two perspectives. First, the VIM SUPERMON Monitor software which handles keyboard display, interrupts and other requirements for system operation must be understood. We will discuss this subject in succeeding sections. The second aspect of software is the microprocessor assembly language with which you will write your applications programs. A brief introduction to the 6502 instruction set is included later in this chapter.

In this chapter, we discuss the VIM-1 command language syntax only briefly; Chapter 5 contains a detailed discussion of each of the instructions in the set. Chapter 6 will help you through the process of using these and the 6502 language in applications programming by describing three selected sample programs.

4.3.1 Monitor Description - General

Figure 9-1 illustrates the general system flow of the VIM-1 SUPERMON Monitor software. As you can tell, the main program is simple and straightforward. Its purpose is to direct processing to the appropriate I/O or command routine, and for this reason it is thought of as a "driver"--it "drives" or directs the software.

The means by which the Monitor handles the direction of software flow is one of the unique features of the VIM-1 system and is worth a brief explanation at this point. We will discuss the subject in greater detail in Chapters 5 and 8.

When the SUPERMON Monitor receives a one- or two-character command from the on-board keyboard, TTY or CRT terminal, it then accepts 0-3 parameters associated with the command. The string of command and parameters (if any) is terminated by the use of a carriage return. It is noteworthy that each instruction which may be entered by use of a single key on the on-board keyboard may also be entered with a similar command from a terminal.

Upon receiving a command and up to three parameters, SUPERMON checks to determine whether the command and its associated number of parameters is a defined combination. If so, the command is exectued. Otherwise, an error message is printed or displayed showing the ASCII representation of the command which was not recognized.

For example, a "GO" with one parameter causes the program to pass control to the program stored at the memory location indicated by the parameter. Thus, a "GO" followed by "0200" instructs the system to begin executing the instructions stored starting at memory location 0200. A "GO" with no parameters (i.e., "GO" followed by a Carriage Return) will cause program execution to resume at the address stored in the "pseudo Program Counter" (memory locations 00FE and 00FF).

However, a "GO" command with two or three parameters is not a defined command in SUPERMON, and will result in a display or message of "Er 47". The "47" is the ASCII representation for a "G" and is designed to help you define the instruction or command which was not recognized.

The monitor is designed so that you can extend the range of defined command-parameter combinations by "intercepting" the error routine before it executes and designing your own series of pointers to memory locations to be associated with specific commands. Thus, you might wish to define a "GET" routine which could be entered at the keyboard with a "GO" and two parameters. You will learn how to do this in Chapter 9.

4.3.2 Software Interfacing

The VIM-1 Monitor is structured to be device-independent. Special requirements for device handling are "outside" the Monitor's central control routines, which isolate them from the Monitor's standard functions. Also, as we have indicated, VIM-1 commands may be entered from any device. It is not necessary to use the on-board keyboard to do so. This means you need not concern yourself with the details of I/O; they are handled internally. Your only task is developing the software to handle the command structure itself, as we described briefly above.

4.3.3 6502 Microprocessor Assembly Language Syntax

The SY6502 microprocessor used on your VIM-1 is an eight-bit CPU, which means that eight bits of data are transferred or operated upon at a time. It has a usable set of 56 instructions used with 13 addressing modes. Instructions are divided into three groups.

Group One instructions, of which there are eight, are those which have the greatest addressing flexibility and are therefore the most general-purpose. These include Add With Carry (ADC), the logical AND (AND), Compare (CMP), the logical Exclusive OR (EOR), Load A (LDA), logical OR with register A (ORA), Subtract With Carry (SBC) and Store Register A (STA).

Group Two instructions include those which are used to read and write data or to modify the contents of registers and memory locations.

The remaining 39 instructions in the SY6502 instruction set are Group Three instructions which operate with the X and Y registers and control branching within the program. You'll learn more about these instructions in the next section. More detailed information can be found in the Synertek Programming Manual for the SY6500 family.

An assembly language instruction consists of the following possible parts:

Label - Optional. Used to allow branching to the line containing the label and for certain addressing situations.

Mnemonic - Required. The mnemonic is a three-character abbreviation which represents the instruction to be carried out. Thus the mnemonic to store the contents of the accumulator in a specific memory location is "STA" (STore Accumulator).

Operand(s) - Some may be required, or none may be allowed. This depends entirely upon the instruction itself and may be determined from the later discussion.

Comment - Optional. Separated from last operand (or from the command mnemonic where no operand is used) by at least one blank. These words, are ignored by the assembler programm but are included only to allow the programmer and others to understand the program.

The SY6502 allows 13 modes of addressing, which makes it one of the most flexible CPUs on the market. Table 4-4 describes these addressing modes briefly. Details may be found in the Synertek Programming Manual for the SY6502 family.

You will note that some of the addressing modes make use of Page Zero, a concept introduced briefly earlier in this chapter. Page Zero addressing modes are designed to reduce memory requirements and provide faster execution. When the SY6502 processor encounters an instruction using Page Zero addressing, it assumes the high-order byte of the address to be 00, which means you need not define that byte in your program. This technique is particularly useful in dealing with working registers and intermediate values. As the Memory Map (Figure 4-10, Sheet 1) shows, memory locations 0000-00FF make up Page Zero.

4.3.4 SY6502 Instruction Set

Table 4-5 provides you with a summary of the SY6502 instruction set. Each instruction is shown with its mnemonic, a brief description of the function(s) it carries out, and the corresponding "op code" for each of its valid addressing modes. The "op code" is the hexadecimal representation of the instruction and is what will appear when the instruction byte is displayed by SUPERMON.

When creating applications programs for your VIM-1, you will typically write them in the SY6502 assembly language mnemonic structure shown in Table 4-5, then perform a "hand assembly" to generate the "op codes" and operands. The process of hand assembling code is explained in greater detail in Section 6.2.2. You will be referring to this table--or to your VIM Reference Card--quite frequently during programming.

To understand some of the instructions, you should be aware of six "status register" flags which are set and reset by the results of program execution. Generally, these flags and their functions are:

N - Set to "1" by CPU when the result of the previous instruction is negative
Z - Set to "1" by CPU when the result of the previous instruction is zero
C - Set to "1" by CPU when the previous instruction results in an arithmetic "carry"
Set to "0" by CPU when the previous instruction results in "borrow" (subtract)
I - When "1," this means IRQ to the CPU is disabled
D - When "1," this means that CPU arithmetic is operating in decimal mode
V - Set to "1" by CPU when the result of the previous instruction causes an arithmetic overflow

No further detail on these status register flags is provided here. The Synertek Programming Manual discusses this subject in greater detail.

Table 4-4. SUMMARY OF SY6502 CPU ADDRESSING MODES

MCS 6502 INSTRUCTION SET SUMMARY

Addressing Modes

Mode	Description	# Bytes	Example		
IMPLIED	The operation performed is implied by the instruction.	1*	TAX	AA	Code for transfer A to X
ACCUMULATOR	The operation is performed upon the A register.	1	ROL A	2A	Code for rotate left A
IMMEDIATE	The data accessed is in the second byte of the instruction.	2	LDA #3	A9 03	Code for load A immediate Constant to use
ZERO PAGE	The address within page zero of the data accessed is in the second byte of the instruction.	2	LDA Z	A5 75	Code for load A zero page Low part of address on page zero
ZERO PAGE INDEXED BY X	The second byte of the instruction plus the contents of the X register (without carry) is the address on page zero of the data accessed.	2	LDA Z,X	B5 75	Code for zero page indexed by X Base address on page zero
ZERO PAGE INDEXED BY Y	The second byte of the instruction plus the contents of the Y register (without carry) is the address on page zero of the data accessed.	2	LDX Z,Y	B6 75	Code for zero page indexed by Y Base address on page zero
ABSOLUTE	The address of the data accessed is in the second and third bytes of the instruction.	3	LDA L	AD 47 02	Code for load A absolute Low part of address High part of address

*Except BRK which is two bytes when not using DEMON.

Table 4-4. SUMMARY OF SY6502 CPU ADDRESSING MODES (Continued)

Mode	Description	# Bytes	Example		
INDEXED BY X	The address in the second and third bytes of the instruction, plus the contents of the X register is the address of the data accessed.	3	LDA L,X	BD 47 02	Code for load A indexed by X Low part of base address High part of base address
INDEXED BY Y	The address in the second and third bytes of the instruction, plus the contents of the Y register is the address of the data accessed.	3	LDA L,Y	B9 47 02	Code for load A indexed by Y Low part of base address High part of base address
INDIRECT PRE-INDEXED BY X	The second byte of the instruction plus the contents of the X register (without carry) is the address on page zero of the two-byte address of the data accessed.	2	LDA (Z,X)	A1 75	Code for load A, indirect pre-indexed by X Base address on page zero
INDIRECT POST-INDEXED BY Y	The contents of the page zero two-byte address specified by the second byte in the instruction, plus the contents of the Y register is the address of the data accessed.	2	LDA (Z),Y	B1 75	Code for load A, indirect post-indexed by Y Base address of page zero
RELATIVE BRANCH	The second byte of the instruction contains the offset (in bytes) to branch address.	2	BEQ LOC	F0 07	Code for branch if equal Seven bytes ahead
INDIRECT JUMP	The address in the second and third bytes of the instruction is the address of the address to which the jump is made.	3	JMP (LOC)	6C 47 02	Code for jump indirect Low part of indirect address High part of indirect address

Table 4-5. SY6502 CPU Instruction Set Summary

6502 INSTRUCTION SET SUMMARY

Instr	Description	Mode													Condition Codes						
		IMP	ACC	IMM	Z	Z,X	Z,Y	ABS	L,X	L,Y	(Z,X)	(Z),Y	REL	IND	N	Z	C	I	D	V	B
ADC	A + M + C → A, C Add memory to accumulator with carry			69	65	75		6D	7D	79	61	71			*	*	*	-	-	*	-
AND	A ∧ M → A "AND" memory with accumulator			29	25	35		2D	3D	39	21	31			*	*	-	-	-	-	-
ASL	C ← 7 6 5 4 3 2 1 0 ← 0 Shift left one bit (memory or accumulator		0A		06	16		0E	1E						*	*	*	-	-	-	-
BCC	Branch on C = 0 Branch on carry clear												90		-	-	-	-	-	-	-
BCS	Branch on C = 1 Branch on carry set												B0		-	-	-	-	-	-	-
BEQ	Branch on Z = 1 Branch on result zero												F0		-	-	-	-	-	-	-
BIT	A ∧ M, M_7 → N, M_6 → V Test bits in memory with accumulator				24			2C							M_7	*	-	-	-	M_6	-
BMI	Branch on N = 1 Branch on result minus												30		-	-	-	-	-	-	-
BNE	Branch on Z = 0 Branch on result not zero												D0		-	-	-	-	-	-	-
BPL	Branch on N = 0 Branch on result plus												10		-	-	-	-	-	-	-
BRK	Forced interrupt PC↓ P↓ Force break	00													-	-	-	1	-	-	1

Table 4-5. SY6502 CPU Instruction Set Summary (Continued)

6502 INSTRUCTION SET SUMMARY

Instr	Description	Mode													Condition Codes						
		IMP	ACC	IMM	Z	Z,X	Z,Y	ABS	L,X	L,Y	(Z,X)	(Z),Y	REL	IND	N	Z	C	I	D	V	B
BVC	Branch on V = 0 Branch on overflow clear												50		-	-	-	-	-	-	-
BVS	Branch on V = 1 Branch on overflow set												70		-	-	-	-	-	-	-
CLC	0 → C Clear carry flag	18													-	-	0	-	-	-	-
CLD	0 → D Clear decimal mode flag	D8													-	-	-	-	0	-	-
CLI	0 → I Clear interrupt disable flag	58													-	-	-	0	-	-	-
CLV	0 → V Clear overflow flag	B8													-	-	-	-	-	0	-
CMP	A - M Compare memory and accumulator			C9	C5	D5		CD	DD	D9	C1	D1			*	*	*	-	-	-	-
CPX	X - M Compare memory and index X			E0	E4			EC							*	*	*	-	-	-	-
CPY	Y - M Compare memory and index Y			C0	C4			CC							*	*	*	-	-	-	-
DEC	M - 1 → M Decrement memory by one				C6	D6		CE	DE						*	*	-	-	-	-	-
DEX	X - 1 → X Decrement index X by one	CA													*	*	-	-	-	-	-

Table 4-5. SY6502 CPU Instruction Set Summary (Continued)

6502 INSTRUCTION SET SUMMARY

Instr	Description	Mode													Condition Codes						
		IMP	ACC	IMM	Z	Z,X	Z,Y	ABS	L,X	L,Y	(Z,X)	(Z),Y	REL	IND	N	Z	C	I	D	V	B
DEY	Y - 1 → Y Decrement index Y by one	88													*	*	-	-	-	-	-
EOR	A ⊻ M → A "Exclusive-Or" memory with accumulator			49	45	55		4D	5D	59	41	51			*	*	-	-	-	-	-
INC	M + 1 → M Increment memory by one				E6	F6		EE	FE						*	*	-	-	-	-	-
INX	X + 1 → X Increment Index X by one	E8													*	*	-	-	-	-	-
INY	Y + 1 → Y Increment index Y by one	C8													*	*	-	-	-	-	-
JMP	(PC + 1) → PCL (PC + 2) → PCH Jump to new location							4C						6C	-	-	-	-	-	-	-
JSR	PC + 2 ↓, (PC + 1) → PCL (PC + 2) → PCH Jump to new location saving return address							20							-	-	-	-	-	-	-
LDA	M → A Load accumulator with memory			A9	A5	B5		AD	BD	B9	A1	B1			*	*	-	-	-	-	-
LDX	M → X Load index X with memory			A2	A6		B6	AE		BE					*	*	-	-	-	-	-
LDY	M → Y Load index Y with memory			A0	A4	B4		AC	BC						*	*	-	-	-	-	-

Table 4-5. SY6502 CPU Instruction Set Summary (Continued)

6502 INSTRUCTION SET SUMMARY

Instr	Description	Mode													Condition Codes						
		IMP	ACC	IMM	Z	Z,X	Z,Y	ABS	L,X	L,Y	(Z,X)	(Z),Y	REL	IND	N	Z	C	I	D	V	B
LSR	0 → [7][6][5][4][3][2][1][0] → [C] Shift right one bit (memory or accumulator)		4A		46	56		4E	5E						0	*	*	-	-	-	-
NOP	No Operation	EA													-	-	-	-	-	-	-
ORA	A V M → A "OR" memory with accumulator			09	05	15		0D	1D	19	01	11			*	*	-	-	-	-	-
PHA	A ↓ Push accumulator on stack	48													-	-	-	-	-	-	-
PHP	P ↓ Push processor status on stack	08													-	-	-	-	-	-	1
PLA	A ↑ Pull accumulator from stack	68													*	*	-	-	-	-	-
PLP	P ↑ Pull processor status from stack	28													From Stack						
ROL	M or A [7][6][5][4][3][2][1][0] ← [C] ← Rotate one bit left (memory or accumulator)		2A		26	36		2E	3E						*	*	*	-	-	-	-
ROR	Rotate One Bit Right (Memory or Accumulator)		6A		66	76		6E	7E						*	*	*	-	-	-	-
RTI	P ↑ PC ↑ Return from interrupt	40													From Stack						
RTS	PC ↑, PC + 1 → PC Return from subroutine	60													-	-	-	-	-	-	-

Table 4-5. SY6502 CPU Instruction Set Summary (Continued)

6502 INSTRUCTION SET SUMMARY		Mode													Condition Codes						
Instr	Description	IMP	ACC	IMM	Z	Z,X	Z,Y	ABS	L,X	L,Y	(Z,X)	(Z),Y	REL	IND	N	Z	C	I	D	V	B
SBC	A - M - $\overline{C}$ → A Note: $\overline{C}$ = Borrow Subtract memory from accumulator with borrow			E9	E5	F5		ED	FD	F9	E1	F1			*	*	*	-	-	*	-
SEC	1 → C Set carry flag	38													-	-	1	-	-	-	-
SED	1 → D Set decimal mode flag	F8													-	-	-	-	1	-	-
SEI	1 → I Set interrupt disable flag	78													-	-	-	1	-	-	-
STA	A → M Store accumulator in memory				85	95		8D	9D	99	81	91			-	-	-	-	-	-	-
STX	X → M Store index X in memory				86		96	8E							-	-	-	-	-	-	-
STY	Y → M Store index Y in memory				84	94		8C							-	-	-	-	-	-	-
TAX	A → X Transfer accumulator to index X	AA													*	*	-	-	-	-	-
TAY	A → Y Transfer accumulator to index Y	A8													*	*	-	-	-	-	-
TSX	S → X Transfer stack pointer to index X	BA													*	*	-	-	-	-	-

Table 4-5. SY6502 CPU Instruction Set Summary (Continued)

6502 INSTRUCTION SET SUMMARY		Mode													Condition Codes						
Instr	Description	IMP	ACC	IMM	Z	Z,X	Z,Y	ABS	L,X	L,Y	(Z,X)	(Z),Y	REL	IND	N	Z	C	I	D	V	B
TXA	X → A Transfer index X to accumulator	8A													*	*	-	-	-	-	-
TXS	X → S Transfer index X to stack pointer	9A													-	-	-	-	-	-	-
TYA	Y → A Transfer index Y to accumulator	98													*	*	-	-	-	-	-

CHAPTER 5

OPERATING THE VIM

In this chapter you will learn how to operate your VIM-1. The keyboard functions are described, formation of monitor commands is discussed, and procedures for using an audio cassette, TTY or CRT are explained.

As you operate your VIM-1, you will be dealing with the system monitor, SUPERMON, which is a tool for entering, debugging and controlling your 6502 programs. The monitor also provides a wealth of software resources (notably subroutines and tables) which are available to your applications programs as they run on the VIM-1 system.

SUPERMON is a 4K-byte program which is stored on a single ROM chip located at addresses 8000-8FFF, as you learned in Chapter 4. It also uses locations 00F8-00FF for special purposes and a special location called "System RAM" located at addresses A600-A7FF. These usages were outlined in detail in Chapter 4 and in the Memory Map.

Operationally, SUPERMON gets commands, parameters and data from its input channels (the HEX Keyboard, HKB; a teletype, TTY; a CRT terminal or RAM memory and others) and, based on this input, performs internal manipulations and various outputs (to the on-board LED display, TTY or CRT terminal screen or other peripheral devices).

5.1 KEYBOARD LAYOUT

The VIM-1 keyboard (see Figure 5-1) consists of 28 color-coded dual-function keys. The characters and functions on the lower half of the keys are entered by pressing the keys directly. To enter the functions shown in the upper halves of the keys, press SHIFT before you press the key you wish to enter. Remove your finger from SHIFT before pressing the second key. Very little pressure is necessary to actuate a key, and except for DEBUG, you will hear an audible tone when the computer senses that a key has been pressed. RST will cause a beep after a short delay.

The functions included on the VIM-1 provide you with a formidable array of programming tools. You can examine and modify the contents of memory locations and CPU registers, deposit binary or ASCII data in memory, move blocks of data from one area of memory to another, search memory for a specific byte, and fill selected memory locations with a specified data byte. You can also store a double byte of data with a single command, display the two's complement of a number, or compute an address displacement.

The RST, DEBUG ON and DEBUG OFF keys do not transmit any characters to the monitor, but perform the functions indicated by their names directly using hardware logic.

5.2 VIM COMMAND SYNTAX

As we have indicated earlier, each VIM-1 command entered from the on-board keyboard or other device may have from 0-3 parameters associated with it. Each command, with its string of parameters, is terminated by a "**CR**" (on the HKB) or a carriage return on a terminal device.

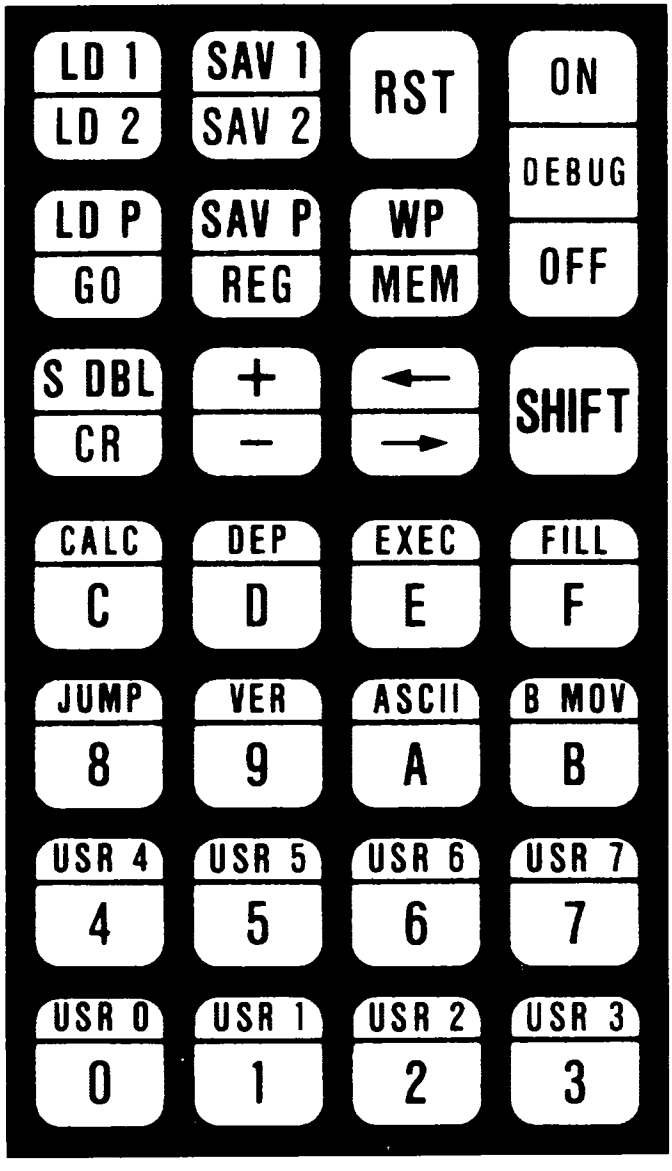


Figure 5-1. VIM-1 KEYBOARD

Table 5-1 summarizes the VIM-1 command set. The first column indicates the command, in both HKB and terminal format. The values (1), (2), and (3) refer to the values of the first, second, and third parameters entered. The term "old" is used to mean the memory location most recently referenced by any of the following commands: M, D, V, B, F, SD, S1, S2, SP, L1, L2, LP. All of these commands use locations 00FE and 00FF as an indirect pointer to memory; where a reference to "old" (or (OLD) in some cases) occurs, the former value remains in the memory pointer locations 00FE-00FF.

Note that in the second column of Table 5-1 we have provided you with the ASCII code for each instruction. Several of the commands do not have associated ASCII codes and use instead a computed "hash code." Hash codes are marked with an asterisk. You need not concern yourself with the means by which the hash code is determined, but you should note that VIM will display these values when the commands are entered with an incorrect syntax, i.e., if you make an error when entering these commands.

Table 5-2 provides you with a brief summary of the additional keys found on the on-board keyboard of the VIM-1. These are operational and special keys which do not generally have parameters associated with them, with the exception of the special user-function keys.

In the discussion of each monitor command which follows, the same basic format is followed. First, the appropriate segment of Table 5-1 is reproduced, for easy reference. Next, the command is described in some detail. Examples are used where they will make understanding the monitor command easier.

Because it is believed that most users of the VIM-1 will ultimately use a TTY to enter and obtain printouts of instruction strings, the remainder of Chapter 5 is designed to use the TTY keyboard function designations rather than those of the on-board keyboard. Remember, though, that both keyboards are functionally the same as far as SUPERMON is concerned. For this reason, we are also using a comma as a delimiter in the command string; the minus sign on the on-board keyboard (or, for that matter, on the TTY or CRT keyboard) may also be used for this purpose.

Table 5-1. VIM-1 COMMAND SUMMARY

Command	Code	Number of Associated Parameters			
HKB/TTY	ASCII	0	1	2	3
MEM M	4D	Memory Examine and modify, begin at (OLD)	Memory Examine and modify, begin at (1)	Memory Search for byte (1), in locations (OLD) - (2)	Memory Search for byte (1), in locations (2) - (3)
REG R	52	Examine and modify user registers PC, S,F,A,X,Y			
GO G	47	Restore all user registers and resume execution at PC	Restore user registers except PC = (1) S = FD, monitor return address is on stack		
VER V	56	Display 8 bytes with checksum beginning at (OLD)	Display 8 bytes with checksum beginning at (1)	Display (1)-(2), 8 bytes per line, with addresses and cumulative checksums	
DEP D	44	Deposit to memory, beginning at (OLD). CRLF/ address after 8 bytes, auto spacing	Deposit to memory, beginning at (1)		
CALC C	43		Calculate 0-(1) or two's complement of (1)	Calculate (1)-(2) or displacement	Calculate (1)+(2)-(3) or displacement with offset
BMOV B	42				Move all of (2) thru (3) to (1) thru (1)+(3)-(2)

Table 5-1. VIM-1 COMMAND SUMMARY (Continued)

Command	Code	Number of Associated Parameters			
HKB/TTY	ASCII	0	1	2	3
JUMP J	4A		Restore user registers except PC= entry (1) of JUMP TABLE, S=FD, monitor return on stack		
SDBL SD	*10			Store high byte of (1) in (2) + 1 then lo byte of (1) in (2), good for changing vectors	
FILL F	46				Fill all of (2) - (3) with data byte (1)
WP W	57		Write protect user RAM according to lo 3 digits of (1)		
LD1 L1	*12	Load first KIM format record found into locations from which it was saved	Load KIM record with ID = (1) into locations from which it was saved	(1) must = FF load first KIM record found, but start at location (2)	
LD2 L2	*13	Load first hi speed record found into locations from which it was saved	load hi speed record with ID = (1)		(1) must = FF load first hi speed record found into (2) - (3)
LDP LP	*11	Load paper tape in demon format. To signal end of file for tape without EOF record, type ;00 **CR** in on-line mode.			

Table 5-1. VIM-1 COMMAND SUMMARY (Continued)

Command	Code	Number of Associated Parameters			
HKB/TTY	ASCII	0	1	2	3
SAVP SP	*1C			Save paper tape locations (1) - (2) in demon format. To create end of file record, unlock punch, switch to local mode, lock punch, type ;00 **CR**	
SAV1 S1	*1D				Save cassette tape locations (2) - (3) with ID = (1) KIM format
SAV2 S2	*1E				Save cassette tape locations (2) - (3) with ID = (1) hi speed format
EXEC E	45		Get monitor input from RAM, starting (1)	Get monitor input from RAM, starting (2) and store (1) for later use	Get monitor input from RAM, starting (3) and store (1) and (2) for later use.

Table 5-2. OPERATIONAL AND SPECIAL KEY DEFINITION (ON-BOARD KEYBOARD ONLY)

Command	ASCII or *Hash Code	Description/Use
CR	OD	Carriage Return (terminates all command strings)
+	2B	Advance eight bytes
-	2D	Retreat eight bytes; also used to delimit parameters
→	3E	Advance one byte or register
←	3C	Retreat one byte
USRO	*14	All USR keys transmit the indicated Hash Code when entered as a command. The same hash codes can be sent from another terminal by entering UO (two characters, no spaces) through U7 as commands. These functions are not defined in SUPERMON and will cause the monitor to vector through the unrecognized command vector. See Chapter 9 for instructions on using this SUPERMON command feature to program your own special functions.
USR1	*15	
USR2	*16	
USR3	*17	
USR4	*18	
USR5	*19	
USR6	*1A	
USR7	*1B	
SHIFT	None	Next key entered is upper position of the selected key.
RST	None	System RESET. System RAM reinitialized to default values
DEBUG ON	None	Turn hardware Debug function "ON"
DEBUG OFF	None	Turn hardware Debug function "OFF"
ASCII	None	Next two keys entered (Hex) will be combined to form one ASCII character (e.g., SHIFT ASCII 4 D followed by a CR is the same as MEM followed by a carriage return).

5.3 VIM-1 MONITOR COMMANDS

5.3.1 M (Display and/or Modify Memory)

Number of Associated Parameters			
0	1	2	3
Memory Examine and modify, begin at (OLD)	Memory Examine and modify, begin at (1)	Memory Search for for byte (1), in locations (OLD)-(2)	Memory Search for byte (1), in locations (2)-(3)

- The standard form for this command uses **one parameter** and is shown below.

M addr **CR**

SUPERMON will then display the address and the byte contained in the location "addr." The following options are then available:

1. Enter 2 Hex digits: bb is replaced and the next address and byte are displayed.

2. Enter single quote (from terminal) and any character: bb is replaced with the ASCII code for the entered character.

3. Enter →or←(>or< from terminal): bb is left unchanged and addr+1 or addr-1, with its contents, is displayed.

4. Enter + or - : bb is left unchanged and addr+8 or addr-8 with its contents, is displayed.

5. Enter **CR** : Return to monitor command mode; bb unchanged.

- Another form of the display memory command uses **no parameter** as shown below:

M CR

This will cause VIM-1 to resume memory examine and modify at (OLD).

- The same memory (M) key may be used to search for a particular byte in memory, using **three parameters** in this form:

M bb,addr1,addr2 **CR**

This instructs the system to search for byte bb from addr1 to addr2. When an occurrence of bb is found, the location and contents are displayed, and all of the standard **M** options described above become available. In addition, a "G" entered following any halt will continue the search.

- Similarly, the **two parameter** sequence:

M bb,addr **CR**

will resume memory search for byte bb from (OLD) to addr.

The following examples demonstrate the various uses of memory display/modify commands. Characters entered by the user are underlined.

One Parameter

```
.M ↓                    Display memory location (OLD); return to Monitor
0215 BB ↓
.

.M A656↓                Display memory location A656
A656 00 0A              Put some data there; return to Monitor
A657 40 ↓
.

.M 200↓                 Display memory location 200
0200 20 'A              Replace data with ASCII code for A
0201 86 'B              Next location displayed; replace data with ASCII B
0202 BB 'C              Next location displayed; replace data with ASCII C
0203 20 ↓               Return to Monitor
.

.M 0200↓                Display memory location 200
0200 41 >               Display next location; data unchanged
0201 42 >               Display next location; data unchanged
0202 43 _               Use space bar for same purpose as arrow
0203 20 _
0204 AF ↓               Return to Monitor
.

.M 0300↓                Display memory location 300
0300 B4 <               Display previous location; data unchanged
02FF BB <
02FE 44 <
02FD BB ↓               Return to Monitor
.

.M 0200↓                Display memory location 200
0200 41 +               Advance 8 bytes and display memory
0208 F0 _               Space used to advance one location; data unchanged
0209 06 _
020A 20 -               Reverse 8 bytes and display memory
0202 43 ↓               Return to Monitor
.

.M 0200↓                Display memory location 200
0200 41 ↓               Return to Monitor
.M↓                     Display (OLD) which is still 200
0200 41 ↓               Return to Monitor
.
```

```
.M 6C,8000,8400↓                    Search for 6C in range 8000-8400
801F,6C,=
8017,29,↓
.V↓
8017 29 10 F0 07 68 AA 68 28,D2
 02D2
.M 6C,8400↓                         Continue search
801F,6C,_
8020,F6,_
8021,FF,G                           Continue search
8026,6C,_
8027,F8,_
8028,FF,↓                           Halt search
.
```

5.3.2 R (Display and/or Modify User Registers)

Number of Associated Parameters			
0	1	2	3
Examine and modify user registers PC,S,F,A,X,Y			

- The only pre-defined form of this command is with **no parameters**, i.e.:

R CR

As soon as the command is entered, the contents of the PC are displayed as follows:

P 8B4A,

Using a forward arrow (→ or >), you may examine the next register. Registers are displayed in the order PC, S, F, A, X, Y, with wrap-around (i.e., PC is displayed after Y). Each register except PC carries a Register Number on the display or TTY printout; S is R1, F is R2, A is R3, X is R4, and Y is R5 (see example below).

To modify the displayed register, enter two or four digits (four only in the case of the PC). The register will be automatically modified and the next will be displayed. A **CR** will cause control to return to the monitor for another command.

In the following example, we have modified the contents of the PC register to become 0200, and the A register to be set to 16. The other registers are not modified and at the conclusion of the complete register cycle and redisplay of PC, a **CR** is used to return to monitor command mode.

```
.R↓
P 8B4A,_                    Display registers
R1  FF,_                    PC; space is used to advance
R2  00,_                    S
R3  00,_                    F
R4  00,_                    A
R5  00,_                    X
P 8B4A,↓                    Y
.                           PC re-displayed; return to Monitor

.R↓
P 8B4A,0200
R1  FF,>
R2  00,_
R3  00,16                   Alter PC = 200, A = 16
R4  00,↓
.
```

5.3.3 G (GO)

Number of Associated Parameters			
0	1	2	3
Restore all user registers and resume execution at PC	Restore user registers except PC = (1) S = FD; monitor return address is pushed onto stack		

- The GO command may be used with **no parameters** to restore all user registers and begin execution at PC:

G CR

- With **one parameter**, the command will restore user registers except that PC is set to addr, S is set to FD and SUPERMON's return address is pushed onto the stack. Thus, if a subroutine return is executed, it will result in a return to monitor command mode (with the user's stack not saved). Its format is as follows:

G addr CR

5.3.4 V (VERIFY)

Number of Associated Parameters			
0	1	2	3
Display 8 bytes with checksum beginning at (OLD)	Display 8 bytes with checksum beginning at (1)	Display (1)-(2), 8 bytes per line, with addresses and cumulative checksums	

- With **one parameter**, this command will result in the display of 8 bytes beginning at addr, with checksum. The format is as follows:

V addr **CR**

In this example, bytes stored in locations 200-207 are displayed, along with their checksum:

```
.V 200↓
0200 41 42 43 20 AF 88 C9 0D,F3
 02F3
.
```

Note that on the on-board display, only the two-byte checksum will be visible.

The checksum is a 16-bit arithmetic sum of all of the data bytes displayed. The low byte is displayed on the data line, and the full checksum on the next. The address is not included in the checksum.

- With **no parameters**, the command will display 8 bytes beginning at (OLD).

V CR

```
.V↓
0200 41 42 43 20 AF 88 C9 0D,F3
 02F3
.
```

- With **two parameters**, the "V" command will display memory from addr1 through addr2. 19 bytes per line are displayed, with cumulative checksums. A single byte checksum is included on each data line, and a final two-byte checksum is printed on a new line.

V addr1,addr2 **CR**

```
.V 8000,8015↓
8000 4C 7C 8B 20 FF 80 20 4A,5C
8008 81 20 71 81 4C 03 80 08,C6
8010 48 8A 48 BA B0 04,5B
 085B
.
```

5.3.5 D (Deposit)

Number of Associated Parameters			
0	1	2	3
Deposit to memory, beginning at (OLD), CRLF/address after 8 bytes, auto spacing	Deposit to memory, beginning at (1)		

- This command is used for entering data to memory from a terminal. With **one parameter**, this command instructs the system to output a **CR** and line feed and print addr. As each two-digit byte is entered, a space is output. If you enter a space (instead of a two-digit byte), you will cause two more spaces to be output, and that memory location will remain unchanged.

D addr CR

```
.D 200↓
0200 A9 3A 85 46 20 13 08 20
0208 EE 08 85 44 84 45 C6 46
0210 D0 F2 60 ↓
.
```

- As with other commands, the "D" with **no parameters** will deposit beginning at (OLD).

D CR

Notice that V and D line up, so that a line displayed with V may be altered with D, as shown below:

```
.V 200↓                                  Verify contents of 0200-0207
0200 A9 3A 85 46 20 13 08 20-09
 0209                                    Checksum
.D↓                                      Deposit memory from 0200; space to advance
0200 _ 0D _ 45 _ 80 03 ↓
.V 200↓                                  Re-verify contents of 0200-0207
0200 A9 0D 85 45 20 80 03 20-43
 0243                                    New checksum
.
```

5.3.6 C (Calculate)

Number of Associated Parameters			
0	1	2	3
	Calculate 0-(1), the two's complement of (1)	Calculate (1)-(2) or displacement	Calculate (1)+(2)-(3) or displacement with offset

This command is used to do Hexadecimal arithmetic. It is very useful in programming to compute operands required for SY6502 instructions.

- With **one parameter**, it calculates 0 minus addr (i.e., the two's complement).

C addr CR

- With **two parameters**, the "C" command will calculate addr1 minus addr2 (i.e., displacement).

C addr1, addr2 CR

- With **three parameters**, the "C" command will calculate addr1 minus addr2 plus addr3 (i.e., displacement with offset).

C addr1,addr2,addr3 CR

5.3.7 B (Block Move in Memory)

Number of Associated Parameters			
0	1	2	3
			Move all of (2) thru (3) to (1) thru (1)+(3)-(2)

- This command is only defined for **three parameters** and is demonstrated by the following examples:

```
.B 200,300,320↓
.
```

Move 300 thru 320 to 200 thru 220.

```
.B 200,220,250↓
.
```

Move 220 thru 250 to 200 thru 230. (The direction of the move is such that no data is lost, even though the regions overlap.)

```
.B 220,200,230↓
.
```

Move 230 thru 200 to 250 thru 220. (Note that this move occurs in the opposite direction. No data is lost.)

5.3.8 J (JUMP)

Number of Associated Parameters			
0	1	2	3
	Restore user registers except PC=entry (1) of JUMP TABLE, S=FD, monitor return pushed on stack		

- This command is only defined for **one parameter.**

J n CR

The parameter, n, must be in the range 0-7. All user registers are restored, except PC is taken from the JUMP TABLE in System RAM, and S=FD. The monitor return address is pushed onto the stack.

(Because the monitor return is on the stack, a JUMP to a subroutine is allowable.)

Note also that certain useful default addresses are inserted in the JUMP TABLE at Reset. (See Memory Map.)

5.3.9 SD (Store Double Byte

Number of Associated Parameters			
0	1	2	3
		Store high byte of (1) in (2)+1 then low byte of (1) in (2). Good for changing vectors	

- This command is defined only for **two parameters** and is most useful for changing vectors.

SD addr1,addr2 **CR**

The example below was used to enter the address of the Hex keyboard input routine into INVEC, in correct order (low byte-high byte). Note that this vector could not have been altered with M, because after one byte had been altered, the vector would have pointed to an invalid address.

```
.SD 89BE,A661↵
.
```

5.3.10 F (Fill)

Number of Associated Parameters			
0	1	2	3
			Fill all of (2)-(3) with data byte (1)

- Defined only for **three parameters**, this command will fill the defined region of memory (addr1-addr2) with a specified byte (bb).

F bb,addr1,addr2 **CR**

For example:

```
.F EA,200,300↓
```

Fill the region 200 thru 300 with the byte EA, which is a NOP instruction.

5.3.11 W (Write Protect)

Number of Associated Parameters			
0	1	2	3
	Write protect user RAM according to 3 digits of (1)		

- This command is defined for only **one parameter.** To unprotect all of user RAM, the command is:

W 0 CR

Its general form is:

W $d_1d_2d_3$ CR

Where each of d_1, d_2, d_3 are the digits 0 (unprotect) or 1 (protect).

d_1 = 400-7FF 1K above first K of RAM
d_2 = 800-BFF 2K above first K of RAM
d_3 = C00-FFF 3K above first K of RAM

For example

```
.W 101↓
.
```

1 protect 400-7FF
0 unprotect 800-BFF
1 protect C00-FFF

Note that write protect applies to extended user RAM on-board, and also that it requires a jumper insertion (see Chapter 4).

5.3.12 E (Execute)

Number of Associated Parameters			
0	1	2	3
	Get monitor input from RAM, starting at (1)	Get monitor input from RAM, starting at (2) and store (1) for later use at A64C	Get monitor input from RAM, starting at (3) and store (1) and (2) for later user at A64E and A64C

- The standard form of the execute command uses **one parameter.**

E addr CR

SUPERMON adjusts its INPUT vectors to receive its input from RAM, beginning at addr. It is assumed that the user has entered a string of ASCII codes into RAM locations beginning at addr, terminated by a byte containing 00. When 00 is encountered, input vectors will be restored. The easiest way to enter these codes is to use the M command with the single-quote option (Section 5.3.1).

When E is used with **two** or **three parameters,** the additional parameters will be stored in system RAM at A64C and A64E. It is the user's responsibility to interpret them. (Note that the E command is vectored; see Chapter 9.)

```
.D 300↓
0300 'C 'F 'F 'E ', 00 ↓
.
```

The sequence at 300 is part of a commonly used Calculate routine.

```
.E 300↓
.C FFFE,200,280↓
 FF7E
.
```

Notice that part of this C command came from RAM, and part was entered at the terminal.

5.4 CASSETTE AND PAPER TAPE COMMANDS

The VIM-1 handles cassette I/O in two formats, KIM-compatible format (8 bytes/sec), and VIM high-speed format (185 bytes/sec).

The S1 and L1 commands refer to KIM format, while the S2 and L2 commands refer to VIM high-speed format.

With each Save command you specify a two-digit ID, as well as starting and ending addresses. The ID, the addresses, and the contents of all memory locations from starting to ending address, inclusive, will be written to tape. Each Save command will create one **RECORD.**

You should be careful to assign unique ID's to different records on the same tape, and to label the tape with the ID's and addresses of all the records it contains.

While VIM is searching for a record or trying to synchronize to the tape, an "S" will be lit in the left-most digit of the display on the on-board keyboard. If the "S" does not turn off, VIM is unable to locate or to read the requested record.

5.4.1 S1, S2 (Save Casette Tape)

Number of Associated Parameters			
0	1	2	3
(S1)			Save cassette tape, locations (2) - (3) with ID = (1) in KIM format
(S2)			Save cassette tape, locations (2) - (3) with ID = (1) in High Speed format

- These commands are discussed together, as their syntax is identical. Recall that S1 refers to KIM format while S2 refers to VIM high-speed format.

Both are defined only for **three parameters.**

S2 bb,addr$_s$,addr$_e$ **CR**

The first parameter is a 2-digit ID, which may be any value other than 00 or FF. It is followed by the starting address and the ending address. In the example below, all memory locations from 0200 thru 0222, inclusive are written to tape, and given the ID 05.

```
.S1 5,200,280
```

5.4.2 L2 (Load High-Speed Format Record)

Number of Associated Parameters			
0	1	2	3
Load first Hi Speed record found into locations from which it was saved	Load Hi Speed record with ID = (1)		(1) must = FF. Load first Hi Speed record found into (2) - (3)

- The standard form of this command uses **one parameter**, as follows:

L2 bb **CR**

The parameter bb is the ID of the record to be loaded. When found, the record will be loaded into memory, using the addresses saved in the record itself.

If the record bb is not the first high-speed record on the tape, the "S" light will go out as VIM reads through, but ignores, the preceding records. After each unselected record is read, the "S" will re-display.

- With **no parameters** (or a single parameter of zero), the instruction will load the first high-speed format record found, without regard to its ID, using the addresses saved in the record itself.

L2 CR

or

L2 0 **CR**

- The L2 command exists in a third form, using **three parameters**, as follows:

L2 FF,addr1,addr2, **CR**

This usage will load a record into a **different** area of memory from where it was saved. The first parameter **must** be FF, followed by the requested starting and ending address. It is your responsibility to supply addr1 and addr2 such that their difference is the same as the difference of the addresses used to save the record.

5.4.3 L1 (Load KIM Format Record From Tape)

Number of Associated Parameters			
0	1	2	3
Load first KIM format record found into locations from which it was saved	Load Kim record with ID = (1) into locations from which it was saved	(1) must = FF. Load first KIM record found, but start at location (2)	

- The L1 command, used with **zero or** with **one parameter**, is identical in syntax to the L2 command (see Section 5.4.2, above).

- With **two parameters**, the L1 command is used to load into a **different region of the memory than that with which the record was saved.**

L1 FF,addr **CR**

The first parameter **must** be FF, followed by the requested starting address. No ending address is necessary, as the load operation will halt when the end of the record is found.

5.4.4 SP (Save Paper Tape)

Number of Associated Parameters			
0	1	2	3
		Save paper tape locations (1) - (2) in DEMON format. To create end of file record, unlock punch, switch to local mode, lock punch, type ;00 **CR**	

- Defined only for **two parameters**, this command will save data from RAM in DEMON paper tape format (see Appendix F).

SP addr1,addr2 **CR**

For example:

```
.SP 200,215↓
;1002003446B743B44BB44BB44BB44BB44BB44BB44BB079A
;060210AC1BF49BD4BB03F0
.
```

5.4.5 LP (Load Paper Tape)

Number of Associated Parameters			
0	1	2	3
Load paper tape in DEMON format. To signal end of file for tape without EOF record, type ;00 **CR** in on-line mode			

- This command is defined for **no parameters** only. It will load memory with data in DEMON paper tape format (see Appendix F).

LP CR

5.5 USER-DEFINED FUNCTIONS

You may, as we have previously pointed out, write programs to be called from the on-board keyboard. You may do this by using any combination of command and number of parameters which is not already defined (e.g., B MOV with only two parameters) or by using any or all of the eight keys along the bottom two rows of the on-board keyboard (those labeled "USR 0" through "USR 7"). The exact means of implementing these special functions is discussed in detail in Chapter 9.

5.6 ERROR CODES

The VIM-1 microcomputer system handles error codes in an interactive way, with codes being designed to be determined by the context in which the error occurs. No table of error conditions and their meanings is therefore provided with this manual, since these are context dependent.

However, you should be aware of the general method by which errors are handled by your VIM-1 system.

When your SUPERMON encounters an error of some type, it displays a 2-digit representation of the byte which was being processed when the error was detected. For example, if you attempt to carry out a CALC command with no parameters (and you haven't defined such a routine yourself as explained in Chapter 9), the system will display a "43." which is the ASCII representation for the "C" which represents the CALC function.

Similarly, if you attempt to use an ID of 00 or FF with either SAV1 or SAV2, the system will display the ID used in error.

After the "er" message is printed, a new prompt (decimal point) is displayed, and SUPERMON waits for a new command. Note that you do not need to RESET when an error condition occurs, since that results in System RAM being cleared and necessitates a re-start of your routine. It is also worth noting that when you carry out an EXEC command at the on-board keyboard the system does not halt when an error occurs; rather, it continues in the same fashion as if new commands were coming directly from the keyboard. The error condition therefore flashes too rapidly on the LED display for you to see it. Command sequences to be executed by EXEC should be pretested prior to such use.

Some fixed error codes do exist in the monitor. Four such codes are used in audio cassette operations and are defined in Table 5-3. Additionally, if in carrying out LD P, FILL or B MOV commands you either attempt to store data in a non-existent or WRITE-protected memory location or if during execution of one of these commands a memory error occurs, the LED display will show the number of locations read incorrectly. This number will always stop at "FF" if it exceeds that number, so that the display will have some intelligible meaning.

Table 5-3. ERROR CODES IN AUDIO CASSETTE OPERATIONS

Code Displayed	Meaning
2F	Last-character error. The last character in a tape record should be a 2F. If that is not the case, the system displays the error code shown.
CC	Checksum error. Usually indicates data transfer problems. Re-position the tape and try again.
FF	In KIM-1 format loading, this error code means a non-Hexidecimal character has been encountered. This almost always means a synchronization error. Restart the procedure.
	In High-Speed format loading, a framing (i.e., synchronization) error is the cause. Restart the procedure.

The following examples provide some representative errors to enable you to become familiar with how they are reported on VIM-1 using a TTY or CRT.

```
.W 111↵
.F EA,300,400↵
ER 01
.
```

Memory location 400 write protected, therefore it could not be modified. One byte only in error.

```
.S2 200,280↵
ER 1E
.
```

S2 is not defined for two parameters. The hash code for S2 is 1E.

```
.C A,230,500,
ER 2C
.
```

Three parameters only permitted.

```
.C 200,2X
ER 58
```

X is not a valid Hex digit.

```
.S2 FF,200,280↵
ER FF
.
```

ID may not be FF or 00.

```
.L2 AA,200,280↵
ER AA
.
```

ID must be FF.

```
.M 6000↵
6000,60,F5?
6001,60,↵
.
```

No RAM at 6000, therefore it cannot be modified.

```
.D 8000↵
8000 AA? DD? ↵
.
```

ROM at 8000, therefore it cannot be modified

```
.D 200,280↵
ER 44
.
```

Deposit not defined for 2 parameters. D = ASCII 44.

```
.F EA,5000,6000↵
ER FF
.
```

No RAM at locations 500-6000, therefore no modification was possible. The number of bytes which were not correctly changed is greater than or equal to 255 (decimal).

CHAPTER 6

PROGRAMMING THE VIM-1

Creating a program on the VIM-1 involves several steps. First, the input to the program and its desired output must be carefully defined. The flow of program logic is usually worked out graphically in the form of a flowchart. Next, the symbols on the flowchart are converted to assembly language instructions. These instructions are in turn translated into machine language, which is entered into memory and executed. If (as usual) the program does not run correctly the first time, you must debug it to uncover the errors in the program. This chapter illustrates the steps involved in creating a program to add two 16-bit binary numbers, and provides two other programming problems with suggested solutions. All three programs are designed to communicate basic programming principles and techniques and to demonstrate a programmer's approach to simple problems.

6.1 HARDWARE

All the sample programs listed here can be loaded and run on the basic VIM-1 with the minimum RAM. The only I/O devices required are the on-board keyboard and display.

If a printing or display terminal is available, by all means use it instead of the Hex keyboard provided. Both types are more comfortable for most users and allow much more data to be displayed at once.

Connect the terminal cable to the appropriate connector on the left edge of the card as described in Chapter 3. Verify that the switches on the terminal are set for full-duplex operation and no parity. The duplexing mode switch will usually be labelled HALF/FULL or H/F; the parity switch will be labelled EVEN/ODD/NO. If your terminal has a CRT, wait for it to warm up. Instructions for "logging on" to a terminal may also be found in Chapter 3.

6.2 DOUBLE-PRECISION ADDITION

Since the eight bits of the accumulator can represent positive values only in the range 0-255 (00-FF Hex), 255 is the largest sum that can be obtained by simply loading one 8-bit number into the accumulator and adding another. But by utilizing the Carry Flag, which is set to "1" whenever the result of an addition exceeds 255, multiple-byte numbers may be added and the results stored in memory. A 16-bit sum can represent values greater than 65,000 (up to FFFF Hex). Adding 16-bit rather than 8-bit numbers is called "double-precision" addition, using 24-bit numbers yields triple precision, etc.

6.2.1 Defining Program Flow

Flowcharting is an orderly way of representing a procedure. Much easier to follow than a list of instructions, a flowchart facilitates debugging and also serves as a handy reference when using a program written weeks or months earlier. Some common flowcharting symbols are shown in Figure 6-1. below.

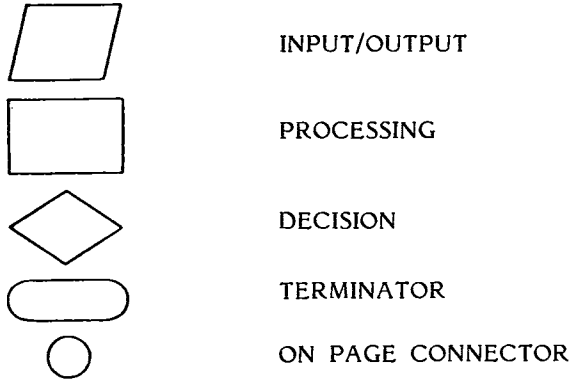


Figure 6-1. COMMON FLOWCHARTING SYMBOLS

The object of our program is to add two 16-bit numbers, each stored in two bytes of RAM, and obtain a 16-bit result. The sequence of operations the processor must perform is shown in the flowchart in Figure 6-2.

To accomplish double-precision addition, first clear the Decimal Mode and the Carry Flags. (The addition is in binary, so the system must not be expecting decimal numbers. The Carry Flag is used in the program and must start at zero.) Load the low byte of the first 16-bit number into the accumulator and add the low order byte of the second number using an Add With Carry (ADC) command. The contents of the accumulator are the low order byte of the result. The Carry Flag is set if the low-byte sum was greater than FF (Hex).

You now store the accumulator contents in memory, load the high order byte of the first number into the accumulator, and add the high order byte of the second number. The ADC command automatically adds the carry bit if it is set. After the second addition, the contents of the accumulator are the high order byte of the result. The example below shows the addition of 384 and 128.

```
      0000  0001  1000  0000     384  (0180 Hex)
      0000  0000  1000  0000     128  (0080 Hex)

      Add low order bytes:  (clear carry)

            1000  0000
            1000  0000
Carry = 1   0000  0000

      Add high order bytes:  (carry = 1)

            0000  0001
            0000  0000
                     1  CARRY
Carry = 0   0000  0010

   Result = 0000 0010  0000  0000 = 512  (0200 Hex)
```

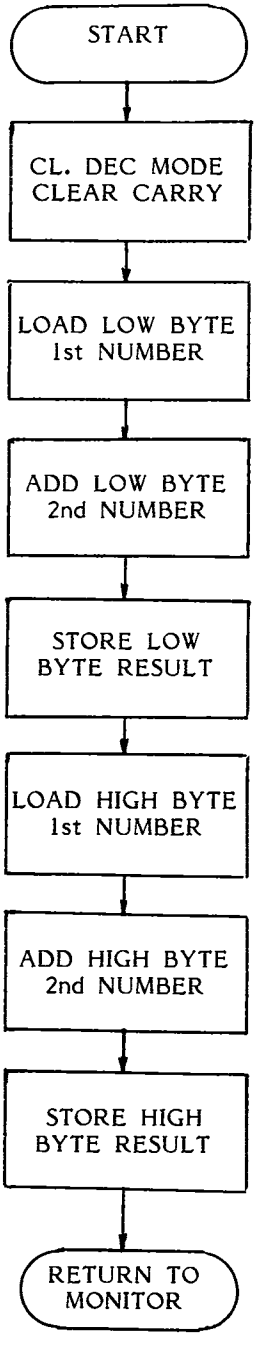


Figure 6-2. DOUBLE-PRECISION ADDITION FLOWCHART

6.2.2 Coding and "Hand Assembly"

Once you have flowcharted a program, you may "code" it onto a form like the one shown in Figure 6-3. SY6502 Microprocessor Assembly Language is described in Sections 4.3.3 and 4.3.4. Additional information is available in the Synertek "Programming Manual" for the 6500 family. Figure 6-4 shows the coding for our example.

The first step involves finding the SY6502 commands that correspond to the operations specified in the flowchart. A summary of the commands and their mnemonic codes is given in Table 4-7. Arbitrary labels were assigned to represent the addresses of the monitor, the two addends and the sum and entered in the operand field. As written, the assembly language program does not specify where in memory the program and data will be stored.

To store and execute the program, you must "assemble" it by translating the mnemonics into hexadecimal command codes and assign the program to a set of addresses in user RAM. Performing this procedure with pencil and paper, rather than with a special assembler program, is "hand assembly".

The SUPERMON monitor begins at Hex location 8000, and the addends and the sum have been arbitrarily assigned to locations 0301 through 0306. You should note that the high and low order bytes of a 16-bit number need not be stored in contiguous locations, although they are in this example.

The program will be stored beginning in location 0200, another arbitrary choice. Data and programs may be stored anywhere in user RAM. Columns B1, B2, and B3 represent the three possible bytes in any 6502 instruction. B1 always contains the Hexadecimal operation code. B2 and B3 represent the operand(s). Looking at the coding form, you can see that the CLD and CLC instructions each occupy one byte and that the LDA instruction occupies three bytes. On your instruction set summary card, you'll see that the LDA mnemonic represents several different operation codes depending on the addressing mode chosen. AD indicates absolute addressing and specifies a three-byte command. When all the operation codes and operands have been translated into pairs of Hex digits, the program is ready to be entered into memory and executed.

6.2.3 Entering and Executing the Program

The procedure for entering the double precision addition program is shown below.

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(RST)		
(CR)	SY1.0..	
(MEM) 200 (CR)	0200.**.	Enter memory display and modify mode
D8	0201.**.	Store D8 in location 0200, advance to next location
18	0202.**.	Store 18 in location 0201, advance to next location
AD	0203.**.	.
02	0204.**.	.
03	0205.**.	.
6D	0206.**.	.
	.	
	.	
	.	
80	0217.**.	
(CR)	217.**..	Exit memory display and modify mode

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ADDR	INSTRUCTIONS B1	B2	B3	LABEL	NMEMONIC	OPERAND	COMMENTS

Figure 6-3. SAMPLE CODING FORM

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DUAL-PRECISION ADD ROUTINE

ADDR	INSTRUCTIONS B1	B2	B3	LABEL	NMEMONIC	OPERAND	COMMENTS
200	D8				CLD		CLEAR DECIMAL MODE FLAG (MODE = 0)
201	18				CLC		CLEAR CARRY FLAG (CARRY=0)
202	AD	02	03		LDA	L1	LOAD LOW ORDER BYTE, FIRST NUMBER
205	6D	04	03		ADC	L2	ADD WITH CARRY, LOW ORDER BYTE, SECOND NUMBER
208	8D	06	03		STA	L3	STORE LOW ORDER BYTE, RESULT
20B	AD	01	03		LDA	H1	LOAD HIGH ORDER BYTE, FIRST NUMBER
20E	6D	03	03		ADC	H2	ADD WITH CARRY HIGH ORDER BYTE, SECOND NUMBER
211	8D	05	03		STA	H3	STORE HIGH ORDER BYTE, RESULT
214	4C	00	80		JMP	START	BRANCH TO MONITOR
301				H1	=	$301	HIGH ORDER BYTE OF FIRST NUMBER
302				L1	=	$302	LOW ORDER BYTE OF FIRST NUMBER
303				H2	=	$303	HIGH ORDER BYTE OF SECOND NUMBER
304				L2	=	$304	LOW ORDER BYTE OF SECOND NUMBER
305				H3	=	$305	HIGH ORDER BYTE OF RESULT
306				L3	=	$306	LOW ORDER BYTE OF RESULT
8000				START	=	$8000	MONITOR

Figure 6-4. DUAL-PRECISION ADD ROUTINE

The program is now entered. Examine each location to make sure that all values are correct. Then store the addend values in locations 0301-0304 as shown below. We'll use the numbers that were used in the example in Section 6.2.1, 0180 (Hex) and 0080 (Hex).

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(MEM) 301 (CR)	0301.**.	
01	0302.**.	Enter high order byte, first addend
80	0303.**.	Enter low order byte, first addend
00	0304.**.	Enter high order byte, second addend
80	0305.**.	Enter low order byte, second addend
(CR)	305.**..	

To execute the program, enter the command shown below.

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(GO) 200 (CR)	g 200.	Execute program starting at location 0200.

Now use MEM to examine locations 0305 and 0306. Verify that they are high and low order bytes of the result, 02 and 00. If you find other data at these locations, you will be pleased to know that the next section of this chapter tells you how to debug the program.

6.2.4 Debugging Methods

The first step in debugging is to make sure that the program and data have been entered correctly. Use the MEM command to examine the program starting address, and use the right-pointing arrow key to advance one location at a time and verify that the contents of each are correct. If you have a terminal, you can generate a listing by entering an SP command without turning on the tape punch or by using the VER command. Also examine the locations that contain the initial data.

If the program and data are correct, but the program still does not execute properly, you may want to use the VIM-1 DEBUG function. If DEBUG is ON when the execute (GO) command is entered, the program will execute the first instruction, then return control to the monitor. The address on the display will be the address of the first byte of the next instruction. If you again press GO to execute (do not specify an address this time), the computer will execute the next instruction, then halt as before. The program may be executed one step at a time in this manner.

After certain instructions, you will want to examine the contents of memory locations or registers. Use the MEM or REG commands, then resume operation by entering another GO command.

To examine the Carry Flag after the low order addition, for example, use the REG command as shown below.

YOU KEY IN	DISPLAY SHOWS	EXPLANATION
(ON)	unimportant	Turn DEBUG function ON
(GO) 200 (CR)	0201.2 .	Execute D8 instruction
(GO) (CR)	0202.2 .	Execute 18 instruction
(GO) (CR)	0205.2 .	Execute AD instruction
(GO) (CR)	0208.2 .	Execute 6D instruction, low order add with carry
(REG) (CR)	P 0208.	Program Counter
	r1 Fd.	Stack pointer
	r2 63.	Status register
(CR)	2 63.	End register examination
(GO) (CR)	020B.2 .	Execute 8D instruction
	.	
	.	

The Carry Flag is the lowest (rightmost) bit of the Status Register. To determine whether the flag was set, convert the Hex digits 63 to binary. The result of this conversion is 0110 0011, and since the low bit is "1", this confirms that the sum of the two low order bytes was greater than 255 (FF Hex).

You may turn the DEBUG switch OFF after any instruction. When you next press GO, the program will finish executing.

Since reading from or writing to any I/O port is the same as reading from or writing to a memory location, the DEBUG feature may also be used to debug I/O operations. When the port address is examined with a MEM command, the two Hex digits that represent data indicate the status of each pin in the port. For example, if C2 is displayed, pin status is as follows:

PIN	7	6	5	4	3	2	1	0
STATUS	1	1	0	0	0	0	1	0

0 = open
1 = closed

For more advanced debugging techniques, including how to write and use your own trace routines, see Sections 9.5 and 9.6.

You now know how to code, enter, and debug programs on the VIM-1. Let's go look at two more examples that illustrate useful programming concepts.

6.3 CONDITIONAL TESTING

Most useful computer programs don't go in straight lines -- they don't simply execute a series of instructions in consecutive memory locations. They do perform different operations for different data by testing data words and jumping to different locations depending on the results of the test. Typical tests answer the following kinds of questions:

1. Is a selected bit of a specified data word a 1 or a 0?
2. Is a specified data word set to a selected ASCII character or numeric value?

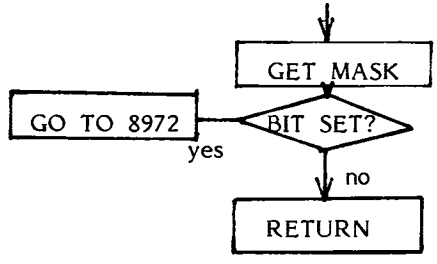
The sample program discussed below will answer question "1". It can be patched easily to answer question "2". You can use the principles you learn in the first two examples to make many more complicated tests.

Bit Testing

This sample program looks at the word in Hex location 31 and tests bit 3. If bit 3 is set to one, it jumps to location 8972; if bit 3 is zero, it returns to the executive. Location 8972 is a monitor subroutine that makes the VIM-1 go "beep".

The only problem involved is in isolating bit 3. The simplest way is to use a mask -- a word in memory with bit 3 set and none other. If we logically AND the mask with the sample word, the resultant value will be zero if bit 3 was zero and non-zero otherwise. The BIT test performs the AND and tests the value without altering the state of the accumulator.

Here is the flow chart. The code is in Figure 6-5. The mask (F7 Hex) is in location 30, the test value in location 31.



Hint

If you wish to test bit 0 or bit 7 of a byte, you need not use a mask. Simply use a shift operation to place the selected bit in the CARRY status bit and use a BCC or BCS to test CARRY. This saves one or more program locations. Note that it alters the accumulator - you may have to shift it back for later processing.

Character, Value, or Magnitude Testing

To test whether a byte is exactly equal to an ASCII character or a value, use the Compare command or first set a mask location exactly equal to the character or value. Then use the EOR command to find the exclusive OR of the two values and test the result for zero. It will be zero if and only if the values were identical. Note that this destroys the test value -- keep another copy of it if you must use it again.

To test whether a byte is greater, equal to, or less than a given value, use the Compare command or set a mask to the test values and subtract it from the test value. The test value will be destroyed. Test the result to see whether it is positive, negative, or zero (this takes two sequential tests) and skip accordingly. Try writing a program that makes a series of magnitude tests to determine whether a given byte is an ASCII control character (0-1F Hex), punctuation mark, number, or letter. The values of the ASCII character set are listed on the summary instruction card.

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BIT 3 TEST ROUTINE

ADDR	INSTRUCTIONS B1	B2	B3	LABEL	NMEMONIC	OPERAND	COMMENTS
30	8			MASK			BIT 3 MASK
31	X			TEST			(USE DIFFERENT VALUES)
200	A9	30			LDA	MASK	GET MASK
202	24	31			BIT	TEST	COMPARE AND SET ZERO BIT
204	FØ	03			BEQ	HOME	NO BIT, RETURN
206	4C	72	89		JMP	BEEP	BEEP ANNUNCIATOR
209	6Ø			HOME	RTS		RETURN

Figure 6-5. BIT 3 TEST ROUTINE

6.4 MULTIPLICATION

The sample program described here multiplies two one-byte unsigned integers and stores the results in two bytes. Note that in any base of two or more, the product of two numbers may be as long as the sum of the lengths of the numbers. In decimal, 99 X 99= 9801; in Hex FF X FF= FE01.

Since many programs will involve multiplication, it is not good practice to write a multiplication routine every time the need comes up. The sample is set up as a subroutine to allow it to be used by many programs. Serious programmers will usually wind up with libraries of subroutines specialized for their applications.

How to Multiply

Multiplication is normally introduced to students as a form of sequential addition. Humans can in fact multiply 22 (decimal) by 13 by performing an addition:

22 + 22 + 22 . . . . 22 = 286

This technique is of course foolish -- it involves a lot of work and a high probability of error. It would be easy to write a program that would multiply this way (try it) but it would be a terrible waste of time.

How then to multiply? We could use a table. Humans use memorized tables that work up to about 10 X 10:

7 X 8 = 56

Humans cannot, however, remember well enough to know that:

22 X 13 = 286

Computers, of course, can "remember" an arbitrarily large table. But the table for the problem at hand would have FFFF entries, which is far too many for practicality.

Humans solve the problem by breaking the multiplication down into smaller steps. We multiply one factor, one digit at a time, by each digit of the other factor in turn. Then we shift some of the partial products to the left and add:

```
    22
X   13
   ---
    66
   22
  ---
  286
```

We would multiply the binary equivalents of the numbers the same way:

```
   10110
    1101
  -------
   10110
      0
  10110
 10110
--------
100011110
```

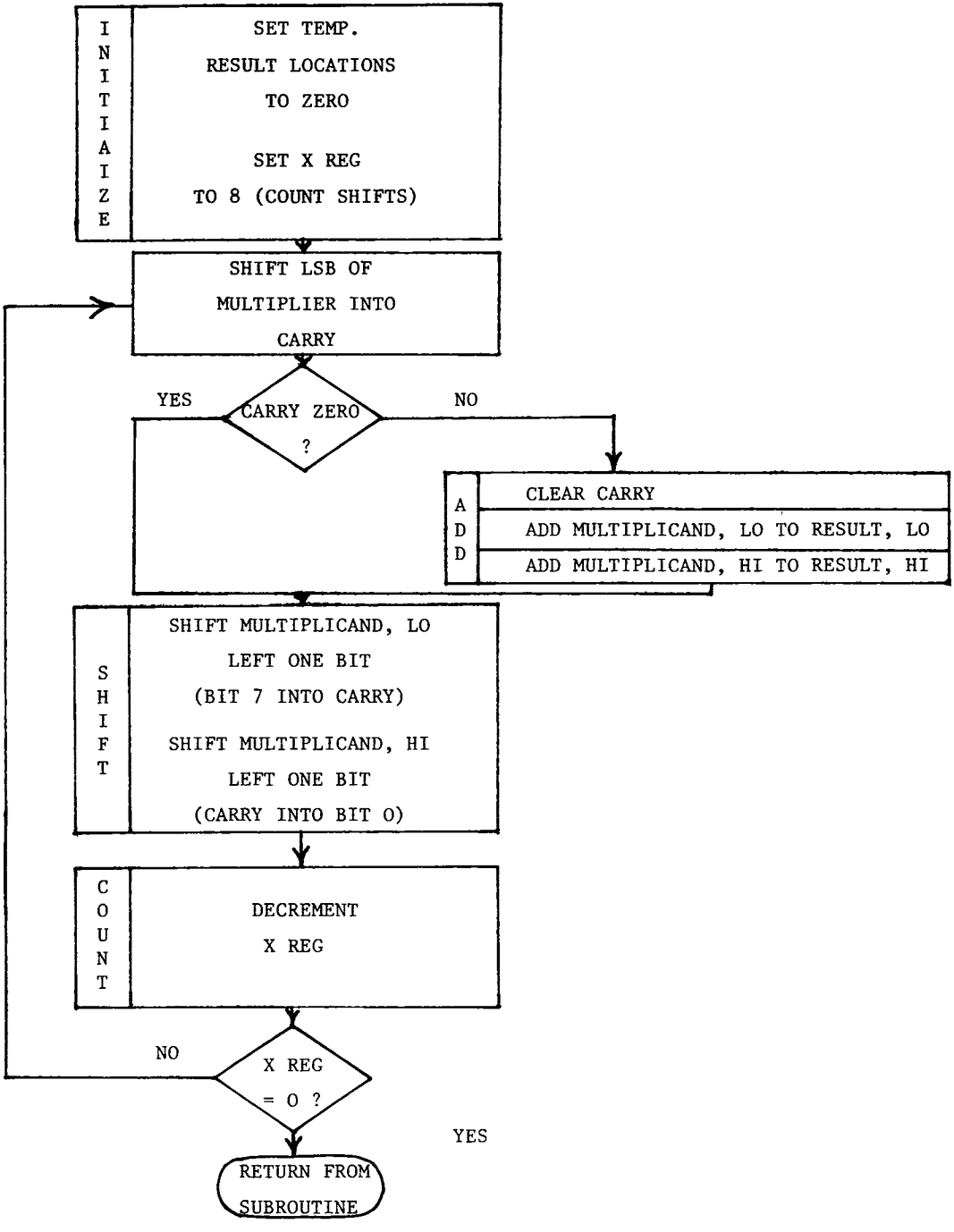

Figure 6-6. GENERAL MULTIPLICATION FLOWCHART

A little figuring will verify that the result is correct. Note that the "tables" for multiplying binary numbers by a single digit are very simple -- a number times one is itself; a number times zero is zero. We can multiply, then, by using a series of additions and shifts, as shown in the flow chart below. The first factor is eight bits long; the second is extended to two bytes (the high-order byte is zero), and the result goes into two bytes set initially to zero. The flowchart in Figure 6-6 is general and not suitable for direct coding.

This procedure could be coded quite easily. Each bit test on the first factor could be made with a different mask as shown in the previous example. Note, however, that the same basic set of instructions is repeated eight times, wasting memory space. A more efficient routine would loop over the same code eight times.

The more efficient routine could also use eight masks, but there's a simpler way. Simply shift the factor to the right once per addition. The bit to be tested will wind up in the CARRY indicator, and we can simply test that. Figure 6-7 is a more formal flowchart of the multiply routine as it is coded that it includes the coding details. The coding chart is shown in Figure 6-8.

Testing

The listing below shows one way to key in the program. The code occupies the RAM space from 200 to 222 Hex. The factor come from locations 21 and 22; the product goes to locations 23 and 24.

Note that the original factors are destroyed by the routine. If it is necessary to preserve them for other subroutines, simply code them into unused memory locations and perform the multiplication on the copies.

Division

Try to write a parallel routine for performing integer division that divides a two-byte quotient and a two-byte remainder. You may wish to test the remainder and, if its MSB is one, round the result by incrementing the quotient.

Arithmetic

The examples given so far show some basic integer arithmetic techniques. They may be expanded easily for dual-precision operation. (Multiply two bytes by two bytes for a four-bit product. Use dual-precision addition and fifteen shifts instead of seven.)

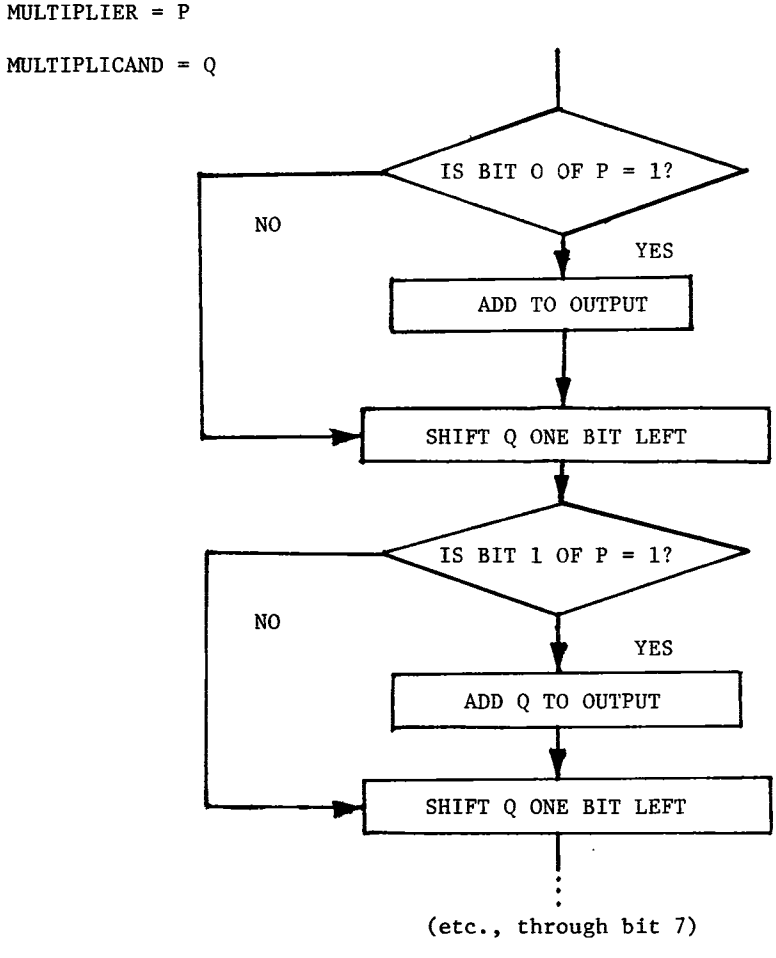

Figure 6-7. DETAILED MULTIPLICATION FLOWCHART

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SINGLE - PRECISION MULTIPLY ROUTINE

ADDR	INSTRUCTIONS B1	B2	B3	LABEL	NMEMONIC	OPERAND	COMMENTS
200	A9	00		MULT1	LDA	#0	ZERO ACCUMULATOR
202	85	20			STA	INHI (20)	SET TEMPORARY STORAGE LOCATION (20) TO ZERO
204	85	23			STA	OUTLO (23)	" LOW BYTE RESULT " (23) " "
206	85	24			STA	OUTHI (24)	" HIGH " " " (24) " "
208	A2	08			LDX	#8	SET X TO 8 TO COUNT SHIFTS
20A	46	22		MORE	LSR	IN2 (22)	SHIFT FACTOR RIGHT
20C	90	0D			BCC	ZERBIT (+D)	IF CARRY = 0 SKIP ADDITION, GO TO ZERBIT
20E	18				CLC		CLEAR CARRY
20F	A5	23			LDA	OUTLO	GET LOW BYTE ASSEMBLED SO FAR
211	65	21			ADC	IN1	ADD CURRENT TERM
213	85	23			STA	OUTLO	SAVE UPDATED LOW BYTE
215	A5	24			LDA	OUTHI	GET HIGH BYTE ASSEMBLED SO FAR
217	65	20			ADC	TEMPHI	ADD CURRENT TERM
219	85	24			STA	OUTHI	SAVE UPDATED HI BYTE
21B	06	21		ZERBIT	ASL	IN1	SHIFT LEFT FOR NEXT ADDITION
21D	26	20			ROL	INHI	SHIFT HIGH BYTE LEFT (ENTER CARRY)
21F	CA				DEX		DECREMENT INDEX REGISTER (COUNT ADDS)
220	D0	E8			BNE	MORE	IF X > 0, GO BACK AND DO NEXT ADD
222	60				RTS		DONE; GO BACK TO CALLING ROUTINE

Figure 6-8. SINGLE-PRECISION MULTIPLY ROUTINE

CHAPTER 7

OSCILLOSCOPE OUTPUT FEATURE

7.1 INTRODUCTION

Your VIM-1 module is hardware-equipped to allow you to use an ordinary oscilloscope as a display device. In this section, we will describe the hardware and connections between the system and the oscilloscope and also provide a listing of a software driver for this output. This listing is just one way of handling the oscilloscope output; you may wish to modify it or develop your own.

7.2 OPERATION OF OSCILLOSCOPE OUTPUT

The circuitry shown in the detail on the schematic (Figure 4-9) enables the VIM to output alphanumeric characters to an oscilloscope. The circuitry is adapted from a published schematic and was included on the VIM to help relieve the bottleneck found on most single-board computers, i.e., the 7 segment displays. Many things can be done with the scope-out circuit, like displaying alphanumeric characters, bar graphs, and game displays. The alphanumeric output is usually organized as 16 or 32 characters, each character being a 5-by-7 dot matrix. The characters could be English, Greek or Cuneiform, or could even be stick-men, cars, dog houses, or laser guns.

The "video" signal from the collector of Q10, is 3V peak-to-peak with a cycle time of about 50 ms (using the suggested software driver included in section 7.3). The sync pulse which begins the line should synchronize all triggered sweep scopes and most recurrent sweep scopes. In the driver which follows, sync could be brought out on a separate pin by replacing the code from SYNC to CHAR with a routine that would output a pulse on PB4 or some other output line.

7.2.1 Connection Procedures

Connect the oscilloscope vertical input to pin R on connector AA ("scope out") and connect scope ground to pin 1 of connector AA (VIM ground). Start the software and adjust the scope for the stable 16-character display. If the sync pulse was output on PB4, connect the scope's trigger to pin 4 of connector AA.

7.2.2 Circuit Operation

The operation of the circuit is simple. Basically, the circuit is a sawtooth waveform generator whose output is sometimes the sawtooth and sometimes ground. The sawtooth is generated by the current source, Q9-Q17-R42-R43, charging C9. When C9 gets up to about 3V the discharge path, Q19-Q18-R41-R44, shorts it back to ground due to a pulse sent out by CA-2. The sawtooth waveform is shown below and forms the columns of the display.

By pulling the sawtooth to ground with Q10 any columns or portions thereof can be "removed" from the display. The result of this can be seen below:

The sawtooth is pulled to ground by bringing CB-2 high.

Because Q10 in the "ON" state will cause loading of C9 (thru R45) and C9 will charge a little more slowly, the time for a "dark" column should be slightly longer than for a "light" column.

If more than 8 vertical dots are desired, the charging rate of C9 must be slowed by lowering the charging current. R42 controls the charging current and can be increased up to about 10K before the loading effects of R45 get completely out of hand.

7.3 USING OUR SOFTWARE

The program listing in Table 7-1 is one way of handling oscilloscope output. After entering the program and character table and attaching an oscilloscope to the scope output, enter the following commands:

	Comments
.SD 500, A670**(CR)**	Change SCANVEC.
.SD 58C, A664**(CR)**	Change OUTVEC.
.SD 560, A661**(CR)**	Change INVEC.

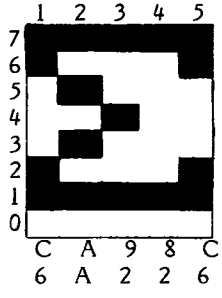
Now enter any stream of characters from the HKB to fill SCPBUF.

Put the scope input on AC couple and the trigger on DC couple. Adjust the time base, attenuation, and trigger until the display becomes readable. If your screen is very small, you may wish to change the number of characters per line by adjusting the value at location $0506.

Example: Creating translation table for scope driver.

Character: $\sum$ (Greek capital letter sigma)

Dot



Hex Equivalent

Each byte corresponds to a single column, with each bit corresponding to a single dot.

sigma = $C6, $AA, $92, $82, $C6

Bit 0 is always 0 to raise the character off of the Ground line.

Table 7-1. OSCILLOSCOPE OUTPUT DRIVER SOFTWARE LISTING

```
LINE # LOC      CODE        LINE

0002  0000                  ; SCOPE LINE DRIVER 05/01/78
0003  0000                  ; USES CHARACTER SET IN TABLE SYMBLS
0004  0000                  ; 5 BYTES PER CHAR
0005  0000                  ; ENTRY 'LINE' IS ANALOGOUS TO 'SCAND'
0006  0000                  ; BELOW ROUTINES HKEY AND HDOUT INTERFACE TO HEX KB
0007  0000                  ; CHAR SET PROVIDED IS FOR HEX KB
0008  0000                  ; AND RELATED TO ASCII TABLE IN MONITOR ROM
0009  0000                  ; THIS DRIVER CAN ACCESS A MAX OF 51 CHARS
0010  0000                  TXTSHV =$8A06
0011  0000                  SCNVEC =$A66F
0012  0000                  GETKEY =$88AF
0013  0000                  KEYQ   =$8923
0014  0000                  SAVER  =$8188
0015  0000                  BEEPP3 =$8975
0016  0000                  ASCIM1 =$8BEE
0017  0000                  RESALL =$81C4
0018  0000                  PCR3   =$ACOC          ;CA2,CB2 = SCOPE
0019  0000                  TXTCTR =$03FE
0020  0000                  COLCTR =$03FF
0021  0000                  TEXT   =$A600          ;SCOPE BUFFER IN SYS RAM
0022  0000                  SYMBLS =$0400          ;CHARACTER TABLE
0023  0000                         *=$500
0024  0500  A9 EE           LINE   LDA #$EE        ;DISCHARGE CAP
0025  0502  8D 0C AC               STA PCR3
0026  0505  A9 21                  LDA #32+1      ;# CHARS PER LINE
0027  0507  8D FE 03               STA TXTCTR
0028  050A  A9 CC           SYNC   LDA #$CC        ;CHARGE CAP FOR SYNC
0029  050C  8D 0C AC               STA PCR3
0030  050F  A2 EA           LDLY   LDX #$EA        ;LONG DELAY !
0031  0511  CA                     DEX
0032  0512  D0 FC                  BNE LDLY+1
0033  0514  CE FE 03         CHAR   DEC TXTCTR      ;LOOP HERE FOR CHAR
0034  0517  AE FE 03               LDX TXTCTR
0035  051A  D0 03                  BNE POIMFG
0036  051C  4C 23 89         EXIT   JMP KEYQ        ;SCAN KB AND RETURN
0037  051F                  ;
0038  051F  BD FF A5         POIMFG LDA TEXT-1,X    ;POINTER MANUFACTURER
0039  0522  0A                     ASL A            ;PTR X 4 + PTR
0040  0523  0A                     ASL A
0041  0524  18                     CLC
0042  0525  7D FF A5               ADC TEXT-1,X     ;MULT'PY BY 5
0043  0528  AA                     TAX
0044  0529  A9 06                  LDA #6
0045  052B  8D FF 03               STA COLCTR
0046  052E  A9 EE           COLUMN LDA #$EE        ;LOOP HERE FOR COL'S
0047  0530  8D 0C AC               STA PCR3         ;DISCHARGE CAP
0048  0533  CE FF 03               DEC COLCTR
0049  0536  30 DC                  BMI CHAR         ;BRANCH IF DONE W/6 COL'S
0050  0538  D0 02                  BNE COLUP
0051  053A  A2 00                  LDX #0           ;INTER CHAR SPACE
0052  053C  A9 EC           COLUP  LDA #$EC        ;START RAMP UP ...
0053  053E  8D 0C AC               STA PCR3         ;... BUT HOLD DOT DOWN
0054  0541  E8                     INX              ;NEXT COL
0055  0542  8A                     TXA              ;SAVE X
0056  0543  48                     PHA
```

Table 7-1. OSCILLOSCOPE OUTPUT DRIVER SOFTWARE LISTING (Continued)

```
LINE # LOC      CODE        LINE

0057   0544   BD FF 03             LDA SYMBLS-1,X   ;GET COL
0058   0547   A0 08                LDY #8           ;COUNT DOTS
0059   0549   88           DOT     DEY
0060   054A   30 0F                BMI CLEAN
0061   054C   4A                   LSR A            ;NEXT DOT IN CARRY
0062   054D   B0 04                BCS LIGHT        ;C SET = LIGHT, C CLEAR = DAR
0063   054F   A2 EC        DARK    LDX #$EC         ;PULL OUTPUT LOW
0064   0551   D0 02                BNE *+4
0065   0553   A2 CC        LIGHT   LDX #$CC         ;OUTPUT FOLLWS RAMP UP
0066   0555   8E 0C AC             STX PCR3
0067   0558   4C 49 05             JMP DOT
0068   055B   68           CLEAN   PLA              ;RESTORE X
0069   055C   AA                   TAX
0070   055D   4C 2E 05             JMP COLUMN
0071   0560                ;
0072   0560                ;
0073   0560   20 AF 88     HKEY    JSR GETKEY       ;GET KEY + ECHO TO SCOPE
0074   0563   20 88 81     SCPDSP  JSR SAVER        ;FILL SCPBUF FROM ASCII IN A
0075   0566   29 7F                AND #$7F
0076   0568   C9 07                CMP #$07         ;BELL?
0077   056A   D0 03                BNE NBELL
0078   056C   4C 75 89             JMP BEEPP3
0079   056F                ; SEARCH ASCII TABLE IN MONITOR ROM
0080   056F   A2 36        NBELL   LDX #$36
0081   0571   DD EE 8B     OUD2    CMP ASCIM1,X
0082   0574   F0 06                BEQ GOTX
0083   0576   CA                   DEX
0084   0577   D0 F8                BNE OUD2
0085   0579   4C C4 81             JMP RESALL       ;NOT IN TABLE
0086   057C   CA           GOTX    DEX
0087   057D   8A                   TXA
0088   057E   C9 0B                CMP #$0B         ;TABLE NOT CONTINUOUS
0089   0580   90 03                BCC GOOD
0090   0582   38                   SEC
0091   0583   E9 05                SBC #5           ;ADJUST DISCONTINUITY
0092   0585   CA           GOOD    DEX
0093   0586   20 06 8A             JSR TXTSHV       ;SHOVE SCPBUF DOWN
0094   0589   4C C4 81             JMP RESALL
0095   058C   20 63 05     HDOUT   JSR SCPDSP       ;CHAR TO SCPBUF AND SINGLE SC
0096   058F   4C 6F A6             JMP SCNVEC
0097   0592                        .END
```

Table 7-1. OSCILLOSCOPE OUTPUT DRIVER SOFTWARE LISTING (Continued)

```
;
; 8X5 MATRIX CHAR SET FOR SCOPE LINE DRIVER
; CONTAINS ALL HEX KB CHARS
; FIRST BYTE OF TABLE MUST BE 00
; EACH CHAR : FIRST BYTE = LEFTMOST COLUMN,
;             MSB = TOP DOT, LSB = 0, BIT 1   BOTTOM DOT
;
*=$400 ;PAGE 4 ALLOCATED TO CHARACTER SET
.BYT $00,$7C,$92,$A2,$7C ;ZERO
.BYT $00,$42,$FE,$02,$00 ;ONE
.BYT $4E,$92,$92,$92,$62 ;TWO
.BYT $44,$82,$92,$92,$6C ;THREE
.BYT $18,$28,$48,$FE,$08 ;FOUR
.BYT $E4,$A2,$A2,$A2,$9C ;FIVE
.BYT $3C,$52,$92,$92,$0C ;SIX
.BYT $86,$88,$90,$A0,$C0 ;SEVEN
.BYT $6C,$92,$92,$92,$6C ;EIGHT
.BYT $60,$92,$92,$94,$78 ;NINE
.BYT $3E,$50,$90,$50,$3E ;A
.BYT $00,$1E,$86,$4A,$32 ;C/R
.BYT $10,$10,$10,$10,$10 ;DASH
.BYT $82,$44,$28,$10,$00 ;RIGHT ARROW
.BYT $FE,$FE,$FE,$FE,$FE ;SH
.BYT $7C,$82,$82,$8A,$4E ;G
.BYT $FE,$90,$98,$94,$62 ;R
.BYT $FE,$40,$30,$40,$FE ;M
.BYT $FE,$02,$02,$02,$02 ;L2
.BYT $44,$A2,$92,$8A,$44 ;S2
.BYT $80,$80,$80,$80,$80 ;U0
.BYT $02,$02,$02,$02,$02 ;U1
.BYT $82,$82,$82,$82,$82 ;U2
.BYT $FE,$00,$00,$00,$00 ;U3
.BYT $FE,$00,$00,$00,$FE ;U4
.BYT $1E,$12,$12,$12,$1E ;U5
.BYT $F0,$90,$90,$90,$F0 ;U6
.BYT $80,$80,$80,$80,$F0 ;U7
.BYT $04,$02,$02,$02,$FC ;J
.BYT $E0,$18,$06,$18,$E0 ;V
.BYT $FF,$FF,$FF,$FF,$FF ;ASCII
.BYT $FE,$92,$92,$92,$6C ;B
.BYT $7C,$82,$82,$82,$44 ;C
.BYT $FE,$82,$82,$82,$7C ;D
.BYT $FE,$92,$92,$82,$82 ;E
.BYT $FE,$90,$90,$80,$80 ;F
.BYT $44,$A2,$92,$8A,$44 ;SD
.BYT $10,$10,$7C,$10,$10 ;+
.BYT $00,$10,$28,$44,$82 ;<
.BYT $00,$00,$00,$00,$00 ;SH
.BYT $FE,$02,$02,$02,$02 ;LP
.BYT $44,$A2,$92,$8A,$44 ;SP
.BYT $FE,$04,$08,$04,$FE ;W
.BYT $FE,$02,$02,$02,$02 ;L1
.BYT $44,$A2,$92,$8A,$44 ;S1
.BYT $00,$06,$06,$00,$00 ;DECIMAL
.BYT $00,$00,$00,$00,$00 ;BLANK
.BYT $40,$80,$8A,$90,$60 ;QUESTION
.BYT $FE,$90,$90,$90,$60 ;P
.END
```

CHAPTER 8

SYSTEM EXPANSION

This chapter discusses the means by which you can expand your VIM-1 microcomputer system by adding memory and peripheral devices to its basic configuration. By now, you realize that data access, whether from RAM, PROM or ROM is a function of addressing interface devices (i.e., 6522's and 6532). Hardware has been built into your VIM-1 module to allow large-scale expansion of the system. A thorough understanding of the VIM-1 System Memory Map (Figure 4-10) will aid considerably in understanding how to expand your system.

8.1 MEMORY EXPANSION

Your VIM-1 module comes equipped with 1K of on-board RAM. It also contains all address decoding logic required to support an additional 3K on-board with no changes by you. In other words, to add 3K of on-board RAM, all you need to do is purchase additional SY2114 devices and plug them into the sockets provided on your board. Your PC board is marked for easy identification of 1K memory blocks. RO equals the lower 1K block and R3 equals the upper 1K block. LO means low order data lines (D0-D3) and HI means high order data lines (D4-D7).

You will recall that the lowest 8K memory locations are defined by an address decoder included on your VIM-1 module (a 74LS138). The eight outputs of this decoder ($\overline{00}$-$\overline{1C}$) each define a 1K block of addresses in the lowest 8K of the Memory Map. Four of the outputs ($\overline{00}$, $\overline{04}$, $\overline{08}$, $\overline{1C}$) are used to select the on-board static RAM. The remaining four outputs ($\overline{10}$, $\overline{14}$, $\overline{18}$, $\overline{1C}$) are used to interface to the Application Connector (Connector "A"), where you can use them to add another 4K of off-board memory. Again, no external decoding logic is required. By this simple means, you can convert your VIM-1 module into an 8K device quickly. Figure 8-1 shows you how to interface these decode lines at the connector for your VIM-1 system.

To go beyond this 8K size, conceivably up to the maximum 65K addressability limit of the VIM CPU, you could build or buy an additional memory board with on-board decoding logic. In this case, you will use the Expansion Connector (Connector "E") in a manner shown schematically in Figure 8-2. Note that the three high-order address bits (AB13-AB15) not used in the earlier expansion are brought to this connector as shown. These are then used with a decoder to create outputs $\overline{M0}$ through $\overline{M7}$, which in turn are used to select and de-select additional decoders (line receivers). You need add only as many decoders (one for each 8K block of memory) as you need for the expansion you require.

Incidentally, the line receivers shown in Figure 8-2 are provided for electrical reasons. There are loading limitations on the address bus lines of the 6502 CPU, which require the insertion of these receivers. (For your information, each 6502 address line is capable of driving one standard TTL load and 130pf of capacity.)

You should make a careful study of the loading limitations of the required VIM-1 lines before deciding on memory expansion size and devices. It is likely you will want to use additional buffer circuits to attain "cleaner" operation of your expanded memory in conjunction with your VIM-1 system.

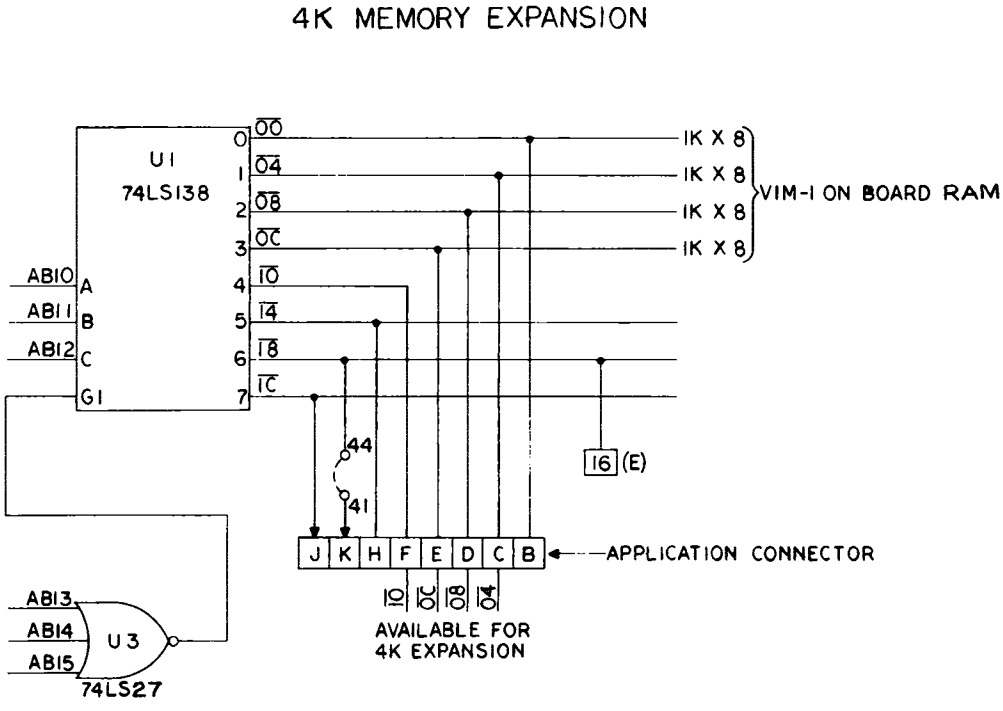


Figure 8-1. 4K MEMORY EXPANSION

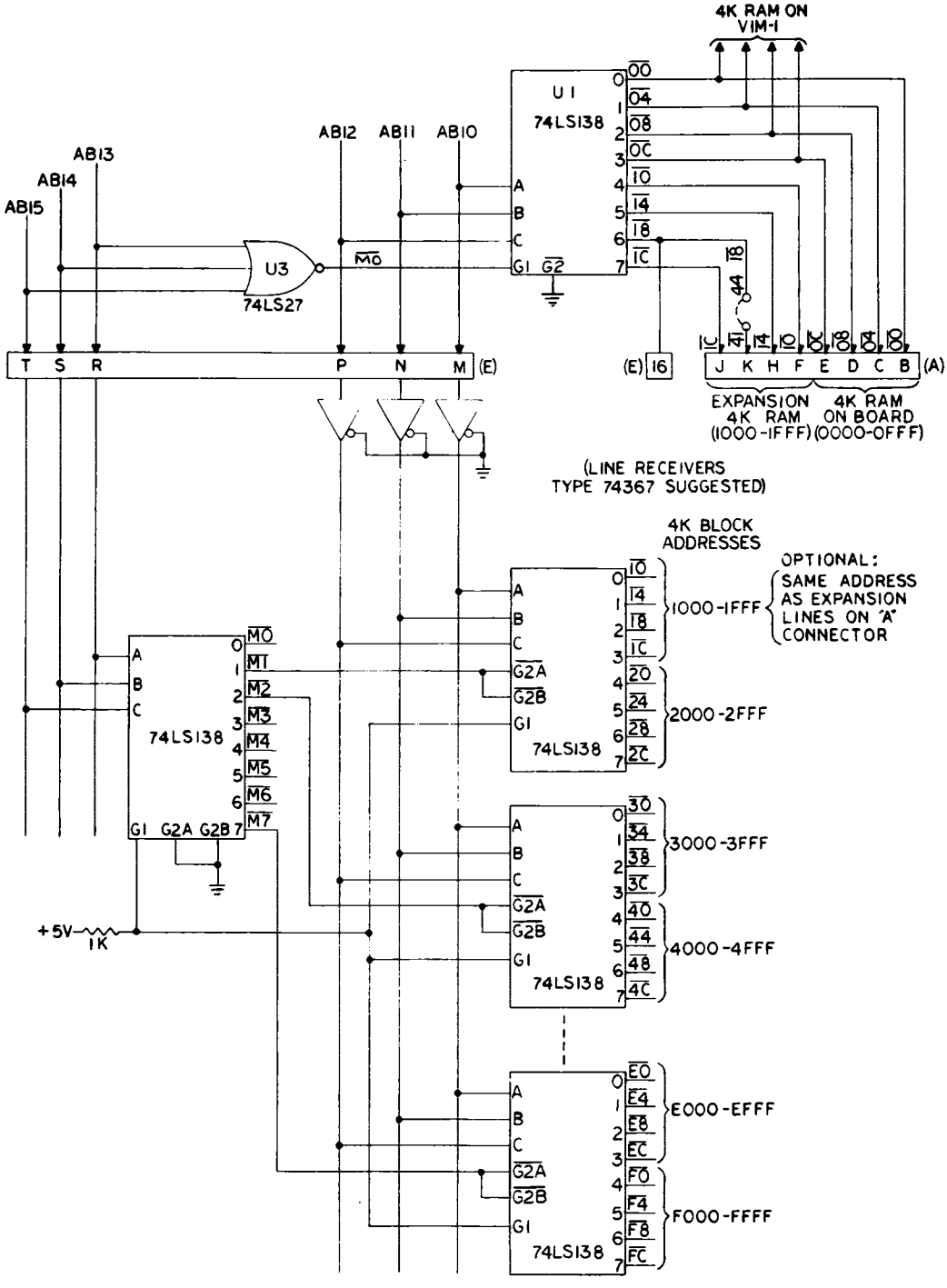


Figure 8-2. MEMORY - I/O EXPANSION TO 65K

8.2 PERIPHERAL EXPANSION

As you already know, the VIM-1 microcomputer system includes 51 I/O lines. This means, theoretically, that you could drive as many as 51 peripheral lines (plus 4 control lines) with your VIM-1.

Using either Application Connector ("A" or "AA"), you can add most commercially available printers or other devices requiring parallel interfaces, although you will have to create your own software driver for the printer. Since the provision of that driver is, to some extent, dependent upon the printer you purchase, we do not attempt to discuss the implementation of the software in this manual.

You can expand your VIM-1 system's peripheral I/O capability easily and quickly merely by installing an additional SY6522 in the socket provided for that device. This will give you 16 additional on-board data lines with no requirement for additional work (beyond the software driver) on your part. To go beyond that level, you must use the Expansion Port (Connector "E") described earlier.

Again, we emphasize that the proper understanding and use of the Memory Map in Figure 4-10 will allow you to use your imagination in expanding the I/O capability of your VIM-1 system. Its flexibility is extremely broad and the fact that all I/O and memory are handled as an addressing function allows you expandability to the full capability of the 6502 CPU itself.

CHAPTER 9

ADVANCED MONITOR AND PROGRAMMING TECHNIQUES

This chapter contains information which you will find useful as you explore the more sophisticated capabilities of your versatile VIM-1 microcomputer system. As we have pointed out many times, the VIM-1 is the most flexible and expandable monitor of its kind. The SUPERMON monitor uses vectors and other techniques to allow you to modify its operation, and these are provided in detail in this chapter. In addition, the extended use of debug and trace facilities, which are invaluable tools as your programming skill advances, are explained. The use of the Hex keyboard provided on your VIM-1 for configurations using a printer (or other serial device) without a keyboard is also described. And last, an example and discussion of extending SUPERMON's command repertoire.

9.1 MONITOR FLOW

SUPERMON is the 4K byte monitor program supplied with your VIM-1. It resides in locations 8000-8FFF on a single ROM chip. It shares the stack with user programs and uses locations 00F8-00FF in Page Zero. In addition, it uses locations A600-A67F (RAM on the 6532), which are referred to as 'System RAM'. Since these locations are dedicated to monitor functions SUPERMON write protects them before transferring control to user programs.

The flowcharts in Figures 9-1 through 9-5 will demonstrate the major structure of SUPERMON. You will notice that GETCOM (and its entry, PARM), DISPAT, and ERMSG are subroutines, and therefore available for your programs' use. Note that a JSR to ACCESS to remove write protection from System RAM is necessary before using most monitor routines. Also, notice that the unrecognized command flow (error) is vectored. Thus, you can extend the monitor with your own software.

9.2 MONITOR CALLS

SUPERMON contains many subroutines and entry points which you will want to use in order to save memory and code and avoid duplication of effort. Table 9-1 is a summary of calls and their addresses.

The two calls which you will most commonly use are:

```
JSR   INCHR     (address 8A1B)
JSR   OUTCHR    (address 8A47)
```

In performing the input/output, these routines save all registers and use INVEC and OUTVEC, so all you need be concerned with when using them are the ASCII characters passed as arguments in the accumulator.

9.3 MONITOR CALLS, ENTRIES AND TABLES

Table 9-1, which occupies the next several pages of this Chapter, provides you with a comprehensive list of important subroutine symbolic names, addresses, registers and functions of SUPERMON monitor calls, entry points and tables. With this data, you can more easily utilize SUPERMON to perform a wide variety of tasks. All (except those marked with an asterisk) are callable by JSR.

Table 9-1. MONITOR CALLS, ENTRIES AND TABLES

NAME	ADDRESS	REGISTERS ALTERED	FUNCTION (S)
*MONITR	8000		Cold entry to monitor. Stack, D flag initialized, System RAM unprotected.
*WARM	8003		Warm entry to monitor
USRENT	8035		User pseudo-interrupt entry - saves all registers when entered with JSR. Displays PC and code 3. Passes control to monitor.
SAVINT	8064	ALL	Saves registers when called after interrupt. Returns by RTS.
DBOFF	80D3	A,F	Simulates depressing debug off key.
DBON	80E4	A,F	Simulates depressing debug on key.
DBNEW	80F6	A,F	Release debug mode to key control.
GETCOM	80FF	A,F	Get command and 0-3 parameters. No error: A=0D (carriage return) Error: A contains erroneous entry.
DISPAT	814A	A,F	Dispatch to execute blocks. Dispatch to URCVEC if error. At return, if error: Carry set, A contains byte in error.
ERMSG	8171	F	If Carry set, print (CR)ER NN, where NN is contents of A.
SAVER	8188	None	Save all registers on stack. At return, stack looks like: F (See paragraph 9.9) A X Y
*RESXAF	81B8	restored	Jumped to after SAVER, restore registers from stack except A,F unchanged, perform RTS.
*RESXF	81BE	restored	Jumped to after SAVER, restore registers from stack except F unchanged, perform RTS.
*RESALL	81C4	restored	Jumped to after SAVER, restore all registers from stack, perform RTS.
INBYTE	81D9	A,F	Get 2 ASCII Hex digits from INCHR and pack to byte in A. If Carry set, V clear, first digit non-Hex. If Carry set, V set, second digit nonHex. N and Z reflect compare with carriage return if Carry set.

Table 9-1. MONITOR CALLS, ENTRIES AND TABLES (Continued)

NAME	ADDRESS	REGISTERS ALTERED	FUNCTION (S)
PSHOVE	8208	X,F	Shove Parms down 16 bits; Move: P2 to P1 P3 to P2 zeros to P3
PARM	8220	A,F	Get 0 to 3 parameters. Return on (CR) or error. A contains last character entered. Flags reflect compare with (CR).
ASCN1B	8275	A,F	Convert ASCII character in A to 4 bits in LO nibble of A. Carry set if non-Hex.
OUTPC	82EE	A,X,F	Print user PC. At return, A=PCL, X=PCH.
OUTXAH	82F4	F	Print X,A (4 Hex digits)
OUTBYT	82FA	A,F	Print A (2 Hex digits)
NIBASC	8309	A,F	Convert LO nibble of A to ASCII Hex in A.
COMMA	833A	F	Print comma.
CRLF	834D	F	Print **(CR) (LF).**
DELAY	835A	F	Delay according to TV. (Relation is approximately logarithmic, base=2). Result of INSTAT returned in Carry.
INSTAT	8386	F	If key down, wait for release. Carry set if key down. (Vectored thru INSVEC)
GETKEY	88AF	A,F	Get key from Hex keyboard (more than one if SHIFT or ASCII key used) return with ASCII or HASH code in A. Scans display while waiting (vectored through SCNVEC).
HDOUT	8900	A,X,Y,F	ASCII character from A to Hex display, scan display once, return with Z=0 if key down.
KEYQ	8923	A,F	Determine if key down on Hex keyboard. If down, then Z=0.
KYSTAT	896A	A,F	Determine if key down. If down, then Carry set.
BEEP	8972	None	BEEP on-board beeper.
HKEY	89BE	A,F	Get key from Hex keyboard and echo in DISBUF. ASCII returned in A. Scans display while waiting (vectored thru SCNVEC)

Table 9-1. MONITOR CALLS, ENTRIES AND TABLES (Continued)

NAME	ADDRESS	REGISTERS ALTERED	FUNCTION (S)
OUTDSP	89C1	None	Convert ASCII in A to segment code, put in DISBUF.
TEXT	8A06	F	Shove scope buffer down, push A onto SCPBUF.
INCHR	8A1B	A,F	Get character (vectored thru INVEC). Drop parity, convert to upper case. If character CTL O (0F), toggle Bit 6 of TECHO and get another.
NBASOC	8A44	A,F	Convert low nibble of A to ASCII, output (vectored thru OUTVEC).
OUTCHR	8A47	None	Output ASCII from A (vectored thru OUTVEC). Output inhibited by Bit 6 of TECHO.
INTCHR	8A58	A,F	Get character from serial ports. Echo inhibited by Bit 7 of TECHO. Baud rate determined by SBBTY. Input, echo masked with TOUTFL.
TSTAT	8B3C	A,F	See if break key down on terminal. If down, then Carry set.
*RESET	8B4A	All	Initialize all registers, disable POR, stop tape, initialize system RAM to default values, determine input on keyboard or terminal, determine baud rate, cold monitor entry.
*NEWDEV	8B64		Determine baud rate, cold monitor entry.
ACCESS	8B86	None	Un-write protect System RAM.
NACCESS	8B9C	None	Write protect System RAM.
*TTY	8BA7	A,X,F	Set vectors, TOUTFL, and SDBTY for TTY.
*DFTBLK	8FA0	Table	Default block - entirely copied into System RAM (A620 - A67F) at reset.
*ASCII	8BEF	Table	Table of ASCII codes and HASH codes.
*SEGS	8C29	Table	Table of segment codes corresponding to ASCII codes (above).

MAIN MONITOR FLOW

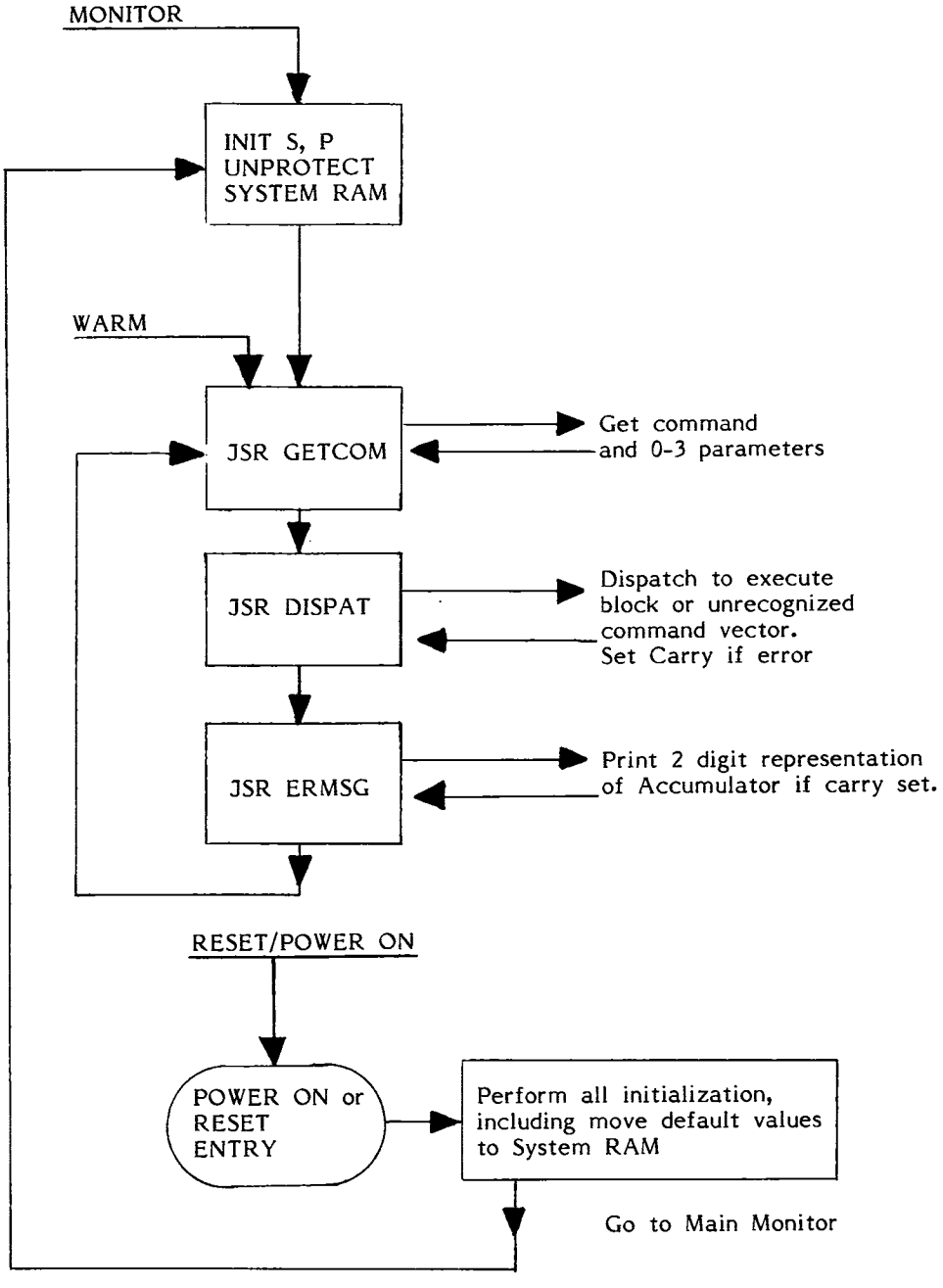


Figure 9-1. MAIN MONITOR FLOW

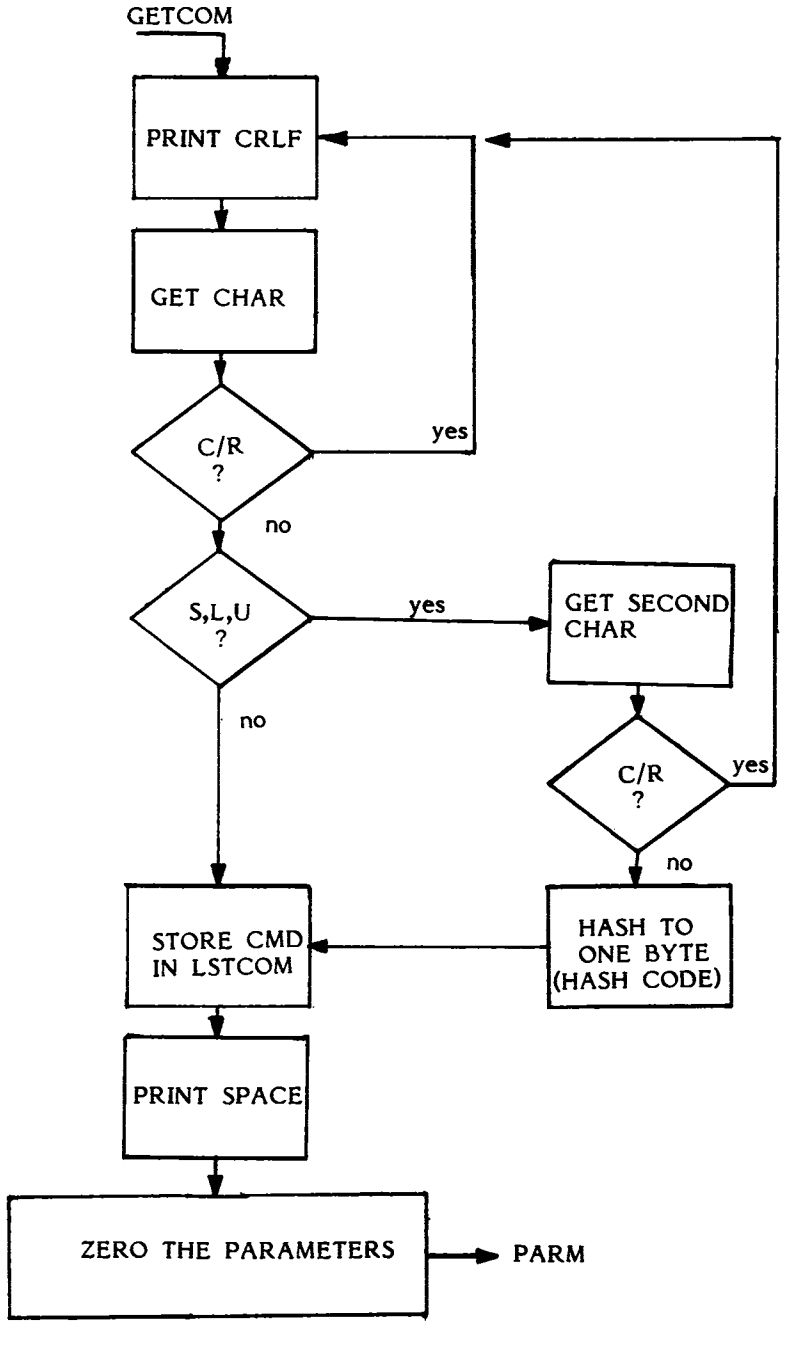


Figure 9-2. GETCOM FLOWCHART

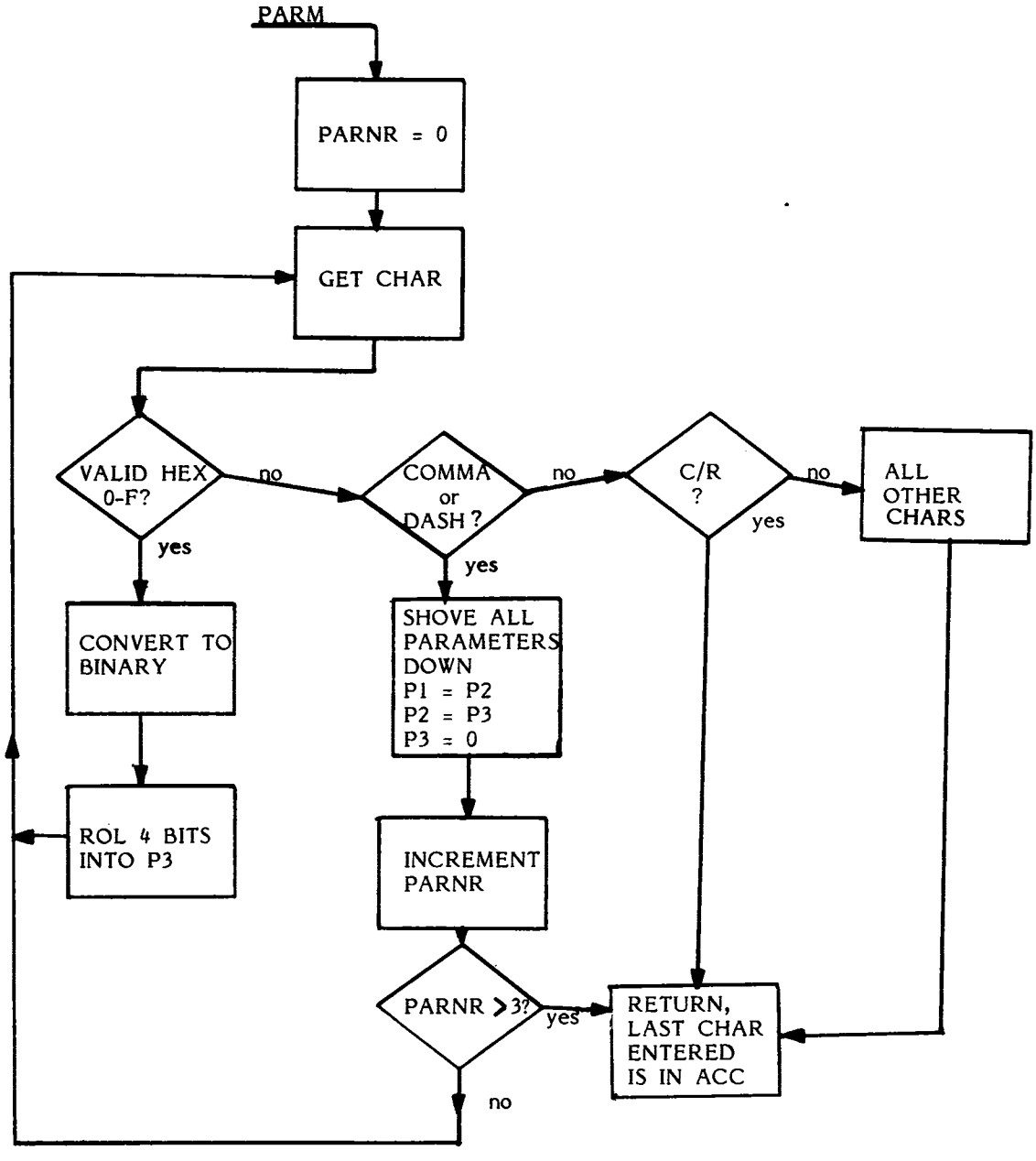


Figure 9-3. PARM FLOWCHART

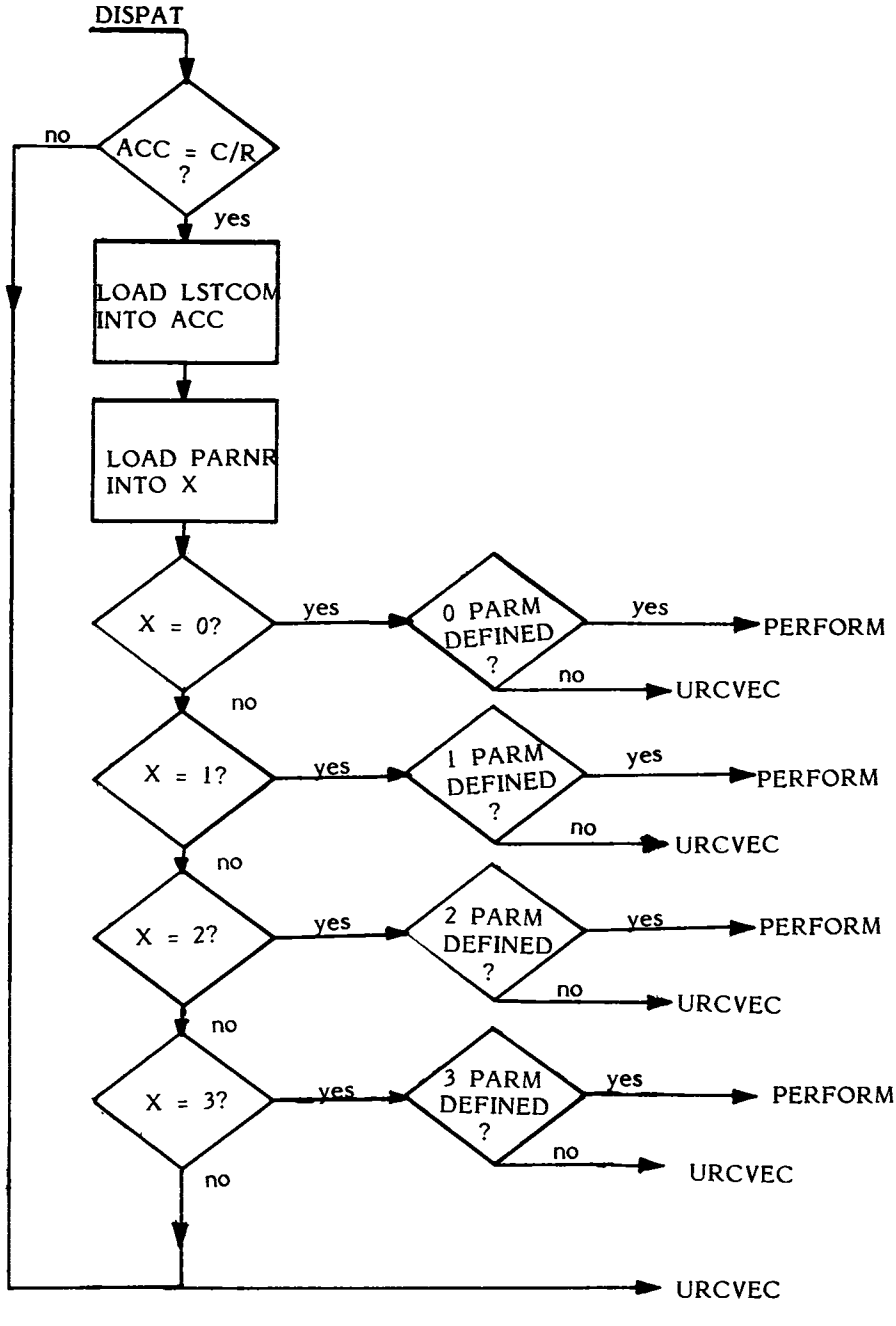


Figure 9-4. DISPAT FLOWCHART

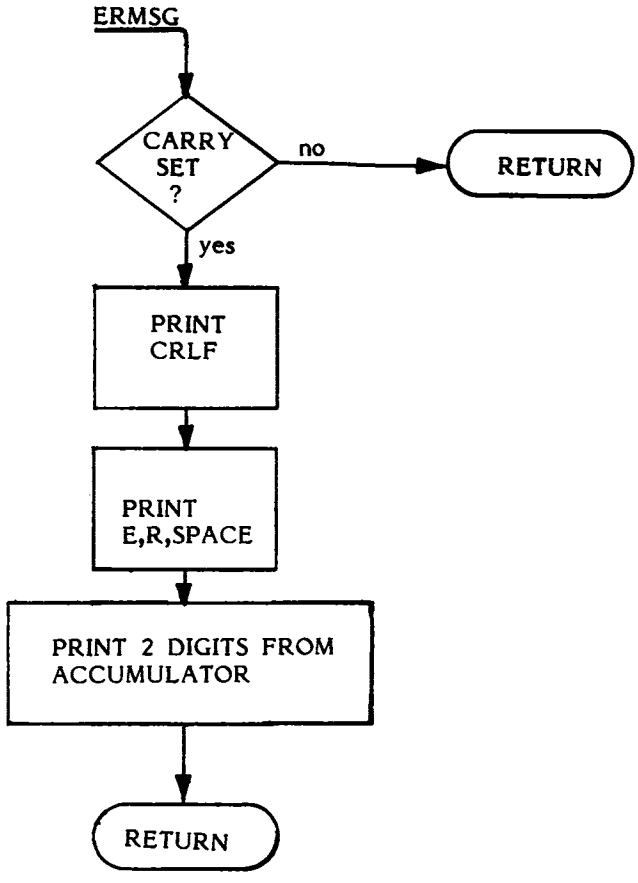


Figure 9-5. ERMSG FLOWCHART

9.4 VECTORS AND INTERRUPTS

A concept which is very important in understanding the SY6502 and SUPERMON is that of a vector pointer. A vector pointer consists of two or three locations at a fixed address in memory. These locations contain an address, or a Hex 4C **(JMP)** and an address. The address is in low-order, high-order byte order.

As an example, consider the function of outputting a character. In some cases, the character is to go to the display, in others to a terminal device. The action required in each case is radically different. It would be inefficient, in code and in time, to make the decision before outputting each character. The solution is a vector pointer. Whenever SUPERMON must output a character, it performs a JSR to OUTCHR. OUTCHR saves all registers, then performs a JSR to OUTVEC (at A663, in System RAM). If you are working at the Hex keyboard OUTVEC will contain a JMP HDOUT. HDOUT is the subroutine which will enter a character, in segment code, into the display buffer. If you are using a TTY or CRT, OUTVEC will contain a JMP TOUT. TOUT is the subroutine which sends a character, one bit at a time, to the serial I/O ports. When HDOUT or TOUT performs an RTS, control passes back to OUTCHR. OUTCHR restores the registers and performs an RTS, returning control to the caller.

Notice that the calling routine need not worry where the output is going. It is all taken care of by OUTCHR and OUTVEC.

When a vector is to be referenced by a JMP Indirect, only two bytes are required. Two-byte vectors are normally used only for interrupts.

An **INTERRUPT** is a method of transferring program control, or interrupting, the processor during execution. There are three interrupts defined on the SY6502:

NMI -- non-maskable interrupt
RST -- reset/power-on
IRQ -- interrupt request

When one of these interrupts occurs, the processor pushes the PC register and the Flags register onto the stack, and gets a new PC from the **INTERRUPT VECTOR.** The interrupt vectors are located at the following addresses:

FFFA,FFFB -- NMI
FFFC,FFFD -- RESET
FFFE,FFFF -- IRQ

These locations must contain the addresses of programs which will determine the cause of the interrupt, and respond appropriately.

In the VIM-1, System RAM (A600-A67F) is duplicated at FF80-FFFF (it is "echoed" there). On Reset, SUPERMON points these vectors to its own interrupt-handling routines. When an interrupt occurs, SUPERMON displays the address where the interrupt occurred with a code indicating the cause of the interrupt.

0 = BRK instruction
1 = IRQ
2 = NMI
3 = USER ENTRY (caused by JSR to USRENT at 8035)

Because all registers are saved, a **(G) (CR)** will cause execution to resume at the point of interruption. The user can intercept interrupt handling by inserting pointers to user interrupt routines in TRCVEC, UBRKVC, NMIVEC, or IRQVEC. See Section 9.7.2 for a discussion of the User Entry pseudo-interrupt. Table 9-2 describes all vectors used by the Monitor.

Table 9-2. SUPERMON VECTORS

NAME	LOCATION	FUNCTION
INVEC	A660-A662	Points to input driver.
OUTVEC	A663-A665	Points to output driver.
INSVEC	A666-A668	Points to routine which determines whether or not a key is down.
URCVEC	A66C-A66E	Unrecognized command. All unrecognized commands and parameter entry errors vectored here. Points to a sequence of: SEC - Set Carry RTS - Return
SCNVEC	A66F-A671	Points to routine which performs one scan of display from DISBUF.
EXEVEC	A672-A673	Points to RIN - get ASCII from RAM subroutine. The Execute (E) command temporarily replaces INVEC with EXEVEC, saving INVEC in SCRA, SCRB. The Hi byte of EXEVEC must be different from the Hi byte of INVEC.
TRCVEC	A674-A675	May be used to point to user trace routine after TRCOFF (See Section 9.6).
UBRKVC	A676-A677	May be used to point to user BRK routine after IRQVEC.
UIRQVC	A678-A679	May be used to point to user NON-BRK IRQ routine after IRQVEC.
NMIVEC	A67A-A67B	Points to routine which saves registers, determines whether or not to trace, based on TV.
IRQVEC	A67E-A67F	Points to routine which saves registers, determines whether or not BRK has occurred, and continues thru UBRKVC or UIRQVC.

9.5 DEBUG ON and TRACE

When the DEBUG ON key on your VIM-1 is depressed, DEBUG mode is enabled. In DEBUG mode, an NMI interrupt occurs every time an instruction is fetched from an address that is not within the monitor. SUPERMON's response is to save the registers and display the PC, with code 2 (for NMI). With each **(G) (CR)**, one instruction of the user program will be executed. This is called Single-Stepping.

In order to TRACE, alter the Trace Velocity (TV, at A656) to a non-zero value. (09 is a good value.) If you now enter **(G) (CR)**, SUPERMON will display the PC and the contents of the accumulator, pause, and resume execution. Addresses and accumulator contents will flash by one at a time. To stop the flow, depress any key (Hex keyboard) or the BREAK key (terminal). Execution will halt. A **(G) (CR)** will resume execution. The length of the delay is related to TV (not linearly; try different values) and, of course, the baud rate, if you are working from a terminal.

9.6 USER TRACE ROUTINES

As the complexity of your programs increases, you may wish to implement other types of trace routines. To demonstrate how this is done, an example of a user trace routine is provided in Figure 9-6. It prints the op code of the instruction about to be executed, instead of the accumulator contents.

But first of all, we don't want to be interrupted during trace mode by responding to an interrupt (a problem called recursion). SUPERMON will handle this by turning DEBUG OFF, then back ON. However, to implement this program control of DEBUG, you must add jumpers to your VIM-1 board (see Chapter 4).

Now that you have added the jumpers, we are ready to enter the program UTRC and change vectors.

First, enter the program UTRC as given in Figure 9-6. Then change NMIVEC to point to TRCOFF, which will save registers, turn DEBUG OFF, and vector thru TRCVEC:

SD 80C0,A67A **(CR)**

Now, point TRCVEC to UTRC.

SD 0380,A674 **(CR)**

Enter a non-zero value in TV, depress DEBUG ON, and you're ready to trace.

NOTE: BRK instructions should not be executed with DEBUG ON.

```
LINE # LOC      CODE        LINE

0002  0000                ; UTRC - USER TRACE ROUTINE -
0003  0000                ; PRINT NEXT OP CODE INSTEAD OF ACCUMULATOR
0004  0000                ;
0005  0000                OPPCOM =$8337          ;PRINT PC, PRINT COMMA
0006  0000                PCLR   =$A659
0007  0000                PCHR   =$A65A
0008  0000                OBCRLF =$834A          ;PRINT BYTE FROM ACC, PRINT CRLF
0009  0000                DELAY  =$835A          ;DELAY BASED ON TV
0010  0000                WARM   =$8003          ;WARM MONITOR ENTRY
0011  0000                TRACON =$80CD          ;TURN TRACE ON, RESUME EXECUTION
0012  0000                TV     =$A656          ;TRACE VELOCITY
0013  0000                ;
0014  0000                       *=$380          ;PUT IN HI RAM (ENTIRELY RELOCATE/
0015  0380  20 37 83     UTRC   JSR OPPCOM      ;PRINT PC, COMMA
0016  0383  AD 59 A6            LDA PCLR        ;USE PC AS PTR TO OP CODE
0017  0386  85 F0               STA $F0
0018  0388  AD 5A A6            LDA PCHR
0019  038B  85 F1               STA $F1
0020  038D  A0 00               LDY #0
0021  038F  B1 F0               LDA ($F0),Y     ;PICK UP OP CODE
0022  0391  20 4A 83            JSR OBCRLF      ;OUTPUT OP CODE, CRLF
0023  0394  AE 56 A6            LDX TV          ;GET TRACE VELOCITY
0024  0397  F0 05               BEQ NOGO        ;NOGO IF ZERO
0025  0399  20 5A 83            JSR DELAY       ;DELAY ACCORDING TO TV
0026  039C  90 03               BCC GO          ;CARRY SET IF KEY DOWN
0027  039E  4C 03 80     NOGO   JMP WARM        ;HALT
0028  03A1  4C CD 80     GO     JMP TRACON      ;CONTINUE
0029  03A4                       .END
```

Figure 9-6. LISTING OF SAMPLE USER TRACE ROUTINE

USER TRACE EXAMPLE

```
.V 200,20A (CR)
  0200 A9 00 A9 11 A9 22 A9 33,0A
  0208  4C 00 02,58
0358
.SD 80C0,A67A (CR)          Vector modification
.SD 380,A674 (CR)           Vector modification
.G 200 (CR)                 Single-Step (Remember
0202,A9                     to set DEBUG ON before
                            each (G) (CR)
 G (CR)
0204,A9

.M A656(CR)
A656,00,09(CR)              Trace Velocity = 9
A657,4D (CR)
.G 200 (CR)
0202,A9
0204,A9
0206,A9
0208,4C                     Continuous trace of op codes
0200,A9
0202,A9
0204,A9
0206,A9
0208,4C
0200,A9
0202,A9
```

9.7 MIXED I/O CONFIGURATIONS

The Reset routine that is activated when power is turned on or RST is pressed establishes the terminal I/O configuration by loading a specified value into a location in System RAM, TOUTFL (A654). The high-order four bits of TOUTFL define which terminal devices may be used for input and output. A "1" signifies that a device is enabled, a "0" that it is disabled. The meaning of each bit and the values assigned at system reset are shown below. The routine referenced by entry (1) in the JUMP table will enable the TTY for input. For other configurations, load the appropriate value into TOUTFL.

TOUTFL bit:	7	6	5	4
default value:	1	0	1	1
meaning:	CRT INPUT	TTY INPUT	TTY OUTPUT	CRT OUTPUT

Bits 6 and 7 of another location in System RAM, TECHO (A653), are used to inhibit serial output (bit 6) and to control echo to a terminal (bit 7). Bit 6 may be toggled by entering "(CONTROL) O" (0F Hex) on the terminal keyboard or in software. The possible values for TECHO are shown below.

TECHO	80	echo output	(default value)
	C0	echo no output	
	40	no echo no output	
	00	no echo output	

With this information, you can alter the SUPERMON standard I/O configurations to suit your special needs. A common use would be routing your output to a terminal while using the Hex keyboard as an input device. Two possible ways of doing this will be discussed.

First, by merely altering SDBYT and OUTVEC, your input and echo will use the on-board keyboard and display, while Monitor and program output will go to the serial device. Choose the proper baud rate value for your device from the following table and put it in SDBYT (at A651) with the "M" command. Then enter the address of TOUT into OUTVEC as follows:

.SD 8AA0,A664 **(CR)**

Terminal Baud Rate	Value Placed in SDBYT
110	D5
300	4C
600	24
1200	10
2400	06
4800	01

Second, if you wish your input to be echoed on the terminal device, a small program must be entered. First, complete the sequence discussed above. Then, enter the following program:

```
UIN   JSR  GETKEY    20  AF  88
      BIT  TECHO     2C  53  A6
      BPL  UOUT      10  03
      JMP  OUTCHR    4C  47  8A
UOUT  RTS            60
```

Enter the program called "UIN" above at any user RAM location. Then use the "SD" command to put the address of UIN into INVEC (at A661) as follows:

.SD (UIN),A661 **(CR)**

where (UIN) is the address of the program UIN.

9.8 USER MONITOR EXTENSIONS

Having read the section on Monitor flow, you will have noticed that unrecognized commands and parameter entries are vectored through URCVEC (A66C-A66E), which normally points to a SEC, RTS sequence at 81D1. By pointing URCVEC to a user-supplied routine in RAM or PROM, SUPERMON can easily be extended. The following example will illustrate the basic principle; many more sophisticated extensions are left to your imagination.

9.8.1 Monitor Extension Example

This example will define U0 with two parameters as a logical AND. The parameters and the result are in Hexadecimal.

```
LOGAND   CMP  LSTCOM     ;CMD loaded?
         BEQ  OK
BAD      SEC              ,      error
         RTS
OK       CMP #$14   ;USR0
         BNE  BAD         ;branch to next
                          ;command if defined
         CPX  #2          ;two parms
         BNE  BAD
DOAND    LDA  P2H
         AND P3H          ;here's the 'and' hi
         TAX
         LDA  P2L
         AND  P3L         ;'and' lo
         JSR  CRLF        ;get new line
         JSR  SPACE
         JMP  OUTXAH      ;PRINT X and A
        .END
```

To attach LOGAND to the monitor, it must be assembled (probably by hand), entered into memory, and URCVEC altered to contain a JMP to LOGAND.

9.8.2 SUPERMON As Extension to User Routines

Because SUPERMON contains a user entry, it can easily be appended to your software. An example of the utility of this feature is a user trace routine, which could have an 'M' command, which would direct it to make SUPERMON available to the user. Here's what the code would look like.

```
UTRACE
. . .                                        Trace code

          JSR INCHR
          CMP #'M
          BNE ELSE
          JSR USRENT
          JMP UTRACE
          . . .

ELSE                                         Code executed if character
                                             input is not 'M.'
```

In this example, the user will type an 'M' to get into monitor, and a **(G) (CR)** to return to the calling portion of UTRACE. Note that the user PC and S registers should not be modified while in monitor if a return to UTRACE is intended.

9.9 USE OF SAVER AND RES ROUTINES

SAVER and the RES routines are designed to be used with subroutines. Their usage is as follows:

```
UPROG    JSR  USUB        USUB      JSR  SAVER
                                       ≀
                                       ≀
                          (USUB CODE)
                                       ≀
                                       ≀
                                    JMP RESALL
```

In this example, UPROG calls USUB. USUB calls SAVER, performs its function, and then jumps to RESALL. RESALL restores all registers and returns to UPROG. If RESXF or RESXAF were used instead of RESALL, UPROG would receive the F, or F and A registers as left by USUB.

APPENDIX A

IMMEDIATE ACTION

Your VIM-1 microcomputer has been thoroughly tested at the factory and carefully packed to prevent damage in shipping. It should provide you with years of trouble-free operation. If your unit does not respond properly when you attempt to apply power, enter commands from the keyboard, or attach peripheral devices to the system, do not immediately assume that it is defective. Re-read the appropriate sections of this manual and verify that all connections have been properly wired and all procedures properly executed.

If you finally conclude that your VIM-1 is defective, you should return it for repair to an authorized service representative. Specific instructions for obtaining a service authorization number and shipping your unit are contained with warranty information on the card entitled "LIMITED WARRANTY AND SERVICE PLAN" that is included with system reference material.

APPENDIX B

PARTS LIST AND COMPONENT LAYOUT

MATERIALS AND ACCESSORIES

QTY.	DESCRIPTION	MANUFACTURER/PART NUMBER
1	CONNECTOR, DUAL 22/44	Microplastic 15622DPIS
1	CONNECTOR, DUAL 6/12	Teka TP3-061-E04
6	RUBBER FEET	3M SJ5018
1	SYNERTEK SOFTWARE MANUAL	
1	VIM-1 WARRANTY/USER CLUB REFERENCE CARD	
1	VIM REFERENCE MANUAL	
1	VIM-1 PC BOARD ASSEMBLY	

VIM-1 PC BOARD COMPONENTS

QTY.	DESCRIPTION	MFR. NO.	REFERENCE DESIGNATION
1	CPU	SYP6502	U5
2	VIA	SYP6522	U25,U29
1	RAM-I/O	SYP6532	U27
2	4K BIT RAM	SYP2114	U12, U13
1	32K BIT ROM	SYP2332	U20
1	NAND GATE	7400	U8
1	HEX INVERTER	7404	U2
1	AND GATE	7408	U24
2	HEX INVERTER-O.C.	7416	U30, U38
1	NAND GATE	74LS00	U4
1	HEX INVERTER	74LS04	U9
1	TRIPLE NOR GATE	74LS27	U3
1	TIMER	555	U6

QTY.	DESCRIPTION	MFR. NO.	REFERENCE DESIGNATION
1	DECODER	74LS138	U1
1	TRIPLE 3 INPUT NAND	74LS10	U7
1	DECODER	74145	U37
2	DECODER	74LS145	U10, U11
1	COMPARATOR	311	U26
9	RES-100 ohm, ¼W, 5%	RF14J100B	R115-122, 128
9	RES-200 ohm, ¼W, 5%	RF14J200B	R43, 53-58, 111, 114
1	RES-300 ohm, ¼W, 5%	RF14J300B	R107
4	RES-470 ohm, ¼W, 5%	RF14J470B	R84, 88, 124, 127
22	RES-1K, ¼W, 5%	RF14J1KB	R9-12, 41, 47-53, 61-63 73, 78, 85, 92, 101, 112, 113, 123
1	RES-1M, ¼W, 5%	RF14J1MB	R72
2	RES-2.2K, ¼W, 5%	RJ14J2.2KB	R103, 108
18	RES-3.3K, ¼W, 5%	RF14J3.3KB	R59, 60, 70, 74, 79-82, 87, 94-95, 97, 98, 102, 105, 106, 109, 126
1	RES-4.7K, ¼W, 5%	RF14J4.7KB	R42
10	RES-10K, ¼W, 5%	RF14J10KB	R45, 67-69, 75, 76, 83, 89, 93, 104
3	RES-47K, ¼W, 5%	RF14J47KB	R44, 46,71
1	RES-330K, ¼W, 5%	RF14J330KB	R77
2	RES-27K, ¼W, 5%	RF14J27KC	R90, 96
1	RES-27 ohm, ¼W, 5%	RF14J27B	R125
2	RES-150 ohm, ¼W, 5%	RF14J150B	R99, 110
1	RES-6.8K, ¼W, 5%	RF14J6.8KB	R100
1	CAP-10pf	DM15100J	C13
13	CAP - .01 mfd, 100V	D8203YZ1032	C1, 3, 5, 7, 10, 11, 16, 19, 21, 23, 25, 27, 29
11	CAP - 10 mfd, 25V	T368B106K025PS	C2, 4, 6, 8, 12, 20, 22, 24, 26, 28, 30

QTY.	DESCRIPTION	MFR. NO.	REFERENCE DESIGNATION
3	CAP - .1 mfd, 50V	3429-050E-104M	C9, 17, 18
1	CAP - .47 mfd	C330C474M5V5EA	C15
1	CAP - .0047 mfd	UR2025100X7R472K	C14
12	NPN TRANSISTOR	2N2222A	Q1-4, 10, 18, 19, 27-29, 32, 33
11	PNP TRANSISTOR	2N2907A	Q9, 17, 20-26, 30-31
11	DIODE, G.P.	1N914	CR25-33, 37, 38
1	DIODE, ZENER	1N4735	CR34
4	SOCKET - 24-PIN DIP	C8424-02	SK20-23
5	SOCKET - 40-PIN DIP	C8440-02	SK5, 25, 27-29
8	SOCKET - 18-PIN DIP	C8418-02	SK12-19
1	DUAL HEADER	929665-01-07	"K" Connector
1	KEYBOARD		KB1
1	PC BOARD		PC1
6	7-SEGMENT DISPLAY, 0.3"	MAN 71A	U31-36
2	LED	RL4850	CR35,36
1	SPEAKER	70057	SP1
1	CRYSTAL	CY1A	Y1

APPENDIX C

AUDIO TAPE FORMATS

HIGH-SPEED FORMAT -- High speed data transfer takes place at 185 bytes per second. Every byte consists of a start bit (0), followed by eight data bits. The least significant bit is transmitted first. A "1" bit is represented by 1 cycle of 3000 Hz, while a "0" bit is represented by 1½ cycles of 1500 Hz. Physical record format is shown below.

8 sec. "mark"	256 SYN chars.	*	ID	SAL	SAH	EAL +1	EAH +1	DATA	/	CKL	CKH	EOT	EOT

8 sec. "mark" - Allows the tape to advance beyond the leader and creates an inter-record gap.

SYN (16 Hex) - ASCII sync characters that allow the VIM-1 to synchronize with the data stream.

* (2A Hex) - ASCII character that indicates the start of a valid record.

ID - Single byte that uniquely identifies the record.

SAL - Low order byte of the Starting Address of data which was taken from memory.

SAH - High order byte of the Starting Address of data which was taken from memory.

EAL +1 - Low order byte of the address following the Ending Address of data which was taken from memory.

EAH +1 - High order byte of the address following the Ending Address of data which was taken from memory.

DATA - Data bytes.

/ (2F Hex) - ASCII character that indicates the end of the data portion of a record.

CKL - Low order byte of a computed checksum.

CKH - High order byte of a computed checksum.

EOT (04 Hex) - ASCII characters that indicate the end of the tape record.

KIM FORMAT -- Data transfer in KIM format takes place at approximately 8 bytes per second. A "1" bit is represented by 18 half-cycles of 3600 Hz followed by 24 half-cycles of 2400 Hz, while a "0" bit is represented by 36 half-cycles of 3600 Hz followed by 12 half-cycles of 2400 Hz. Each 8-bit byte from memory is represented by two ASCII characters. The byte is separated into two half-bytes, then each half-byte is converted into an ASCII character that represents a Hex digit. The least significant bit is transmitted first. The KIM physical record format is shown below.

128 SYN chars.	*	ID	SAL	SAH	DATA	/	CKL	CKH	EOT	EOT

The ASCII characters SYN, "*" (2A Hex) and "/" (2F Hex) as well as ID, SAL, SAH, CKL, CKH and EOT serve the same functions as in HIGH-SPEED format. Sync characters, *, / and EOT are represented by single ASCII characters, while the remaining record items require two ASCII characters. Note that EAL and EAH are not used in the KIM format.

APPENDIX D

PAPER TAPE FORMAT

When data from memory is stored on paper tape, each 8-bit byte is separated into two half-bytes, then each half-byte is converted into an ASCII character that represents a Hex digit (O-F). Consequently, two ASCII characters are used to represent one byte of data. In the paper tape record format shown below, each N, A, D, and X represents one ASCII character.

; N_1N_0 $A_3A_2A_1A_0$ $(D_1D_0)_1$ $(D_1D_0)_2$ . . . $(D_1D_0)_n$ $X_3X_2X_1X_0$

;	- Start of record mark
N_1N_0	- Number of data bytes in (Hex) contained in the record
$A_3A_2A_1A_0$	- Starting address from which data was taken
(D_1D_0)-$(D_1D_0)_n$	- Data
$X_3X_2X_1X_0$	- 16-bit checksum of all preceding bytes in the record including N_1N_0 and $A_3A_2A_1A_0$, but excluding the start of record mark.

A single record will normally contain a maximum of 16 (10 Hex) data bytes. This is the system default value that is stored in system RAM at power-up or reset in location MAXRC (A658). You can substitute your own value by storing different number in MAXRC. To place an end of file after the last data record saved, place the TTY in local mode punch on, and enter ;00 followed by **(CR).**

APPENDIX E

VIM COMPATABILITY WITH KIM PRODUCTS

If you are a VIM-1 user who has peripheral devices which you have previously used with the KIM system or software which has been run on a KIM module, you'll find VIM to be generally upward compatible with your hardware and software. The following two sections describe the levels of compatability between the two systems to allow you to undertake any necessary modifications.

E.1 HARDWARE COMPATABILITY

Table E-1 describes the upward compatability between VIM and KIM at the Expansion (E) connector, while Table E-2 describes the compatability on the Applications (A) connector.

I/O port addresses differ between the two systems; you should consult the Memory Map in Figure 4-10 for details.

Power Supply inputs are provided on a separate connector with VIM-1, which means that if you have been using your power supply with a KIM device it will be necessary to rewire its connections to use the special connector on the VIM-1 board.

E.2 SOFTWARE COMPATABILITY

Table E-3 lists important user-available addresses and routines in the KIM-1 monitor program and their counterparts in VIM-1's SUPERMON. Many of the routines do not perform identically in the two systems, however, and you should check their operation in Table 9-1 before using them.

Table E-1. EXPANSION CONNECTOR (E) COMPATABILITY

VIM DESCRIPTION	VIM NAME	PIN #	KIM NAME	KIM DESCRIPTION
Jumper (Y,26) Selectable: OFF - Open Pin ON - Debug On/Off Output (U8-8)	DBOUT	17	SSTOUT	From ($\overline{\text{SYNC}}$ • NOT MONITOR) U26-6
Power On Reset Signal Output: "0" After power on "1" When reset by software	$\overline{\text{POR}}$	18		No equivalent

Table E-2. APPLICATION CONNECTOR (A) COMPATABILITY

VIM DESCRIPTION	VIM NAME	PIN #	KIM NAME	KIM DESCRIPTION
Jumper (V,23) Selectable: OFF - Open Pin ON - Remote Audio Control Out	AUD.RC	N	+12V	+12V Not required on VIM
Jumper (HH,41) Selectable: OFF Open Pin ON $\overline{\text{ICXX}}$ Decode Out		K	DECODE Enable	Enable 8K Decoder

Table E-3. VIM-KIM SOFTWARE COMPATABILITY

VIM		KIM		FUNCTION
Label	Address(es)	Label	Address(es)	
PCLR	A659	PCL	00EF	Program Counter - low
PCHR	A65A	PCH	00F0	Program Counter - high
FR	A65C	P	00F1	Status Register
SR	A65B	SP	00F2	Stack Pointer
AR	A65D	A	00F3	Accumulator
YR	A65F	Y	00F4	Y - Register
XR	A65E	X	00F5	X - Register
SCR6	A636	CHKHI	00F6	Checksum - low
SCR7	A637	CHKSUM	00F7	Checksum - high
P2L	A64C	SAL	17F5	Start Addr Low - audio/paper tape
P2H	A64D	SAH	17H6	Start Addr High - audio/paper tape
P3L	A64A	EAL	17F7	End Addr+1 Low - audio/paper tape
P3H	A64B	EAH	17F8	End Addr+1 High - audio/paper tape
P1L	A64E	ID	17F9	ID Byte audio Tape
NMIVEC	A67A-B FFFA-B	NMIV	17FA-B FFFA-B	NMI Vector
RSTVEC	FFFC-D	RSTV	17FC-D FFFC-D	Reset Vector
IRQVEC	A67E-F FFFE-F	IRQV	17FE-F FFFE-F	IRQ Vector
DUMPT	8E87	DUMPT	1800	Dump memory to audio tape
LOADT	8C78	LOADT	1873	Load memory from audio tape
CHKT	8E78	CHKT	194C	Compute checksum for audio tape
OUTBTC	8F4A	OUTBTC	195E	Output one KIM byte
HEXOUT	8F52	HEXOUT	196F	Convert LSD of A to ASCII AND write to audio tape

Table E-3. VIM-KIM SOFTWARE COMPATABILITY (Continued)

VIM		KIM		FUNCTION
Label	Address(es)	Label	Address(es)	
OUTCHT	8F5D	OUTCHT	197A	Write one ASCII character to audio tape
RDBYT	8E2C	RDBYT	19F3	Read one byte from audio tape
PACKT	8E3E	PACKT	1A00	Pack ASCII to nibble
RDCHT	8E61	RDCHT	1A24	Read one character from audio tape
RDBITK	8E0F	RDBIT	1A41	Read one bit from tape
SVNMI	809B	SAVE	1C00	Monitor NMI entry
RESET	8B4A	RST	1C22	Monitor RESET entry
OUTPC	82EE	PCCMD	1CDC	Display PC
INCHR	8A1B	READ	1CGA	Get character
LP2B+7	841E	LOAD	1CE7	Load paper tape
SP2B+4	869C	DUMP	1D42	Save paper tape
OUTS2	8319	PRTPNT	1E1E	Print pointer
OUTBYT	82FA	PRTBYT	1E3B	Print 1 byte as 2 ASCII character
INCHR	8A1B	GETCH	1E5A	Get character
DLYF	8AE6	DELAY	1ED4	Delay 1 bit time
DLYH	8AE9	DEHALF	1EEB	Delay ½ bit time
INSTAT	8386	AK	1EFE	Determine if key is down
OUTDSP	89C1	SCAND	1F19	Output to LED display
SCAND	8906	SCANDS	1F1F	Scan LED display
INCCMP	82B2	INCPT	1F63	Increment pointer
GETKEY	88AF	GETKEY	1F6A	Get key
CHKSAD	82DD	CHK	1F91	Compute checksum
INBYTE	81D9	GETBYT	1F9D	Get 2 Hex characters and pack

APPENDIX F

CREATING AND USING A SYNC TAPE

To read serial data from tape, the VIM-1 makes use of synchronizing (sync) characters that are part of every tape record. For a complete description of audio tape record formats, refer to Appendix C.

When the VIM-1 searches for a record, an "S" is displayed until the sync characters are recognized and data transfer begins. However, if the volume and tone controls on the recorder are not set correctly, the sync characters will not be recognized, the "S" on the display will not go out, and the record will not be loaded into memory.

Before attempting to save and load data for the first time, or whenever the control levels have been changed since the recorder was last used, you should perform a load operation using a tape containing only sync characters. By adjusting the volume and tone controls until the displayed "S" goes out, you can set the control levels properly for actual data.

You may want to generate two sync tapes, one for HIGH-SPEED format, the other for KIM format, just once, and save them for future use.

To generate a sync tape, enter the sync character generation program for one of the formats into RAM starting in location 0200 (Hex). The assembly language code and the machine language code for both formats are shown below. Read the pairs of Hex digits from left to right and top to bottom. For example, the code for HIGH-SPEED format should be entered in the following sequence: A0 80 20 B6 8D A9 . . . .

Next, insert a tape into the cassette unit. If the unit is equipped with remote control, place it in Record mode. Set the volume and tone controls to mid-range, then enter the command to execute the program:

(GO) 200 (CR)

If you are operating the cassette controls manually, place the unit in Record mode after entering the command, but before entering (CR). Remote controlled units will advance the tape automatically. Let the tape run for several minutes, then press RST to end the program. For manual operation, also press STOP on the tape unit.

To set the volume and tone controls for loading data into memory, rewind the tape to the beginning (you may need to pull out the Remote jack or keep your finger on RST), then place the unit in Play mode if it is equipped with remote control. Next, enter the load command for the appropriate format ((LD 1) for KIM, (LD 2) for HIGH-SPEED, followed by a carriage return (CR)).

If you have a manually operated unit, place it in Play mode after entering the command. While the tape advances, adjust the volume and tone controls until the "S" on the display goes out and remains out, then press RST and stop the tape.

You can now remove the sync tape and proceed to save and load actual programs and data.

SYNERTEK SYSTEMS CORPORATION
2589 Scott Boulevard
Santa Clara, California 95050
(408) 247-8940

PROGRAM SYNC TAPE

PROGRAMMER SYNERTEK SYSTEMS

DATE 5-78

ADDR	INSTRUCTIONS B1	B2	B3	LABEL	NMEMONIC	OPERAND	COMMENTS
						MODE = $80	HIGH-SPEED; USE $00 FOR KIM
						OUTCHT = $8F5D	
						OUTBTH = $8F17	
						TAPOUT = $A402	
						START = $8DB6	
						* = $200	
	A0	80			LDY	#MODE	IN KIM, A0 00
	20	B6	8D		JSR	START	IN KIM, 20 B6 8D
	A9	07			LDA	#7	IN KIM, A9 07
	8D	02	A4		STA	TAPOUT	IN KIM, 8D 02 A4
	A9	16		SYNMOR	LDA	#$16	IN KIM, A9 16
	20	17	8F		JSR	OUTBTH	HIGH-SPEED; USE JSR OUTCHT (20 5D 8F) KIM
	4C	0A	02		JMP	SYNMOR	IN KIM, 4C 0A 02

APPENDIX G

SY6502 DATA SHEET

Synertek®

MOS and CMOS Integrated Circuits

MARCH 1978

Memory Products

Static Shift Registers

SY2533	1024x1, 1.5MHz, Dual Input
SY2833	1024x1, 2MHz, Dual Input
SY2833A	1024x1, 3MHz, Dual Input
SY2833B	1024x1, 4MHz, Dual Input
SY2833C	1024x1, 5MHz, Dual Input
SY2535/2535A	480x2, 1.5MHz/3MHz, Recirculate
SY2534/2534A	512x2, 1.5MHz/3MHz, Recirculate

Dynamic Shift Registers

SY2401/2401-1	1024x2, 1MHz/2.5MHz, Recirculate
SY2825A	1024x2, 6MHz, Common Recirculate
SY2826	1024x2, 6MHz
SY2827	2048x1, 6MHz, Recirculate
SY1402A/2802	256x4, 5MHz/10MHz, Low Power, Low Capacitance
SY1403A/2803	512x2, 5MHz/10MHz, Low Power, Low Capacitance
SY1404A/2804	1024x1, 5MHz/10MHz, Low Power, Low Capacitance

Static Random Access Memories

SY21H02/-2	1024x1, 175/200nsec
SY2102A-2	1024x1, 250nsec, 65mA
SY2102A-4/-6	1024x1, 450/650nsec, 55mA
SY21L02A/B	1024x1, 350nsec/400nsec, 30mA
SY2102-1	1024x1, 500nsec, 55mA
SY21L02-1	1024x1, 500nsec, 40mA
SY21L02	1024x1, 1000nsec, 15mA
SY21H01/-2	256x4, 175/200nsec, Separate I/O
SY2101-1	256x4, 500nsec, 70mA, Separate I/O
SY2101A/-2/-4	256x4, 350/250/450nsec, 55mA, Separate I/O
SY21H11/-2	256x4, 175/200nsec, Common I/O
SY2111-1	256x4, 500nsec, 70mA, Common I/O
SY2111A/-2/-4	256x4, 350/250/450nsec, 55mA, Common I/O
SY21H12/-2	256x4, 175/200nsec, Common I/O
SY2112-1	256x4, 500nsec, 70mA, Common I/O
SY2112A/-2/-4	256x4, 350/250/450nsec, Common I/O
SY2114/-3/-2	1024x4, 450/300/200nsec, 18 pin
SY2114L/-3/-2	1024x4, 450/300/200nsec, 70mA, 18 pin
SY2114LV/-3/-2	1024x4, Power Down, 450/300/200nsec, 70mA
SY2142/-3/-2	1024x4, 450/300/200nsec, 20 pin
SY2142L/-3/-2	1024x4, 450/300/200nsec, 20 pin, 70mA
SY2142LV/-3/-2	1024x4, 450/300/200nsec, Power Down, 20 pin, 70mA
SY2147	• 4096x1, 55nsec, 160mA operating, 20mA standby
SY5101L/-3	CMOS, 256x4, 650nsec, 200/10µA Standby, Power Down
SY5101L-1	CMOS, 256x4, 450nsec, 10µA Standby, Power Down
SY5101-8	CMOS, 256x4, 800nsec

Memory Products

Static Read Only Memories

SY2530	512x8, 550nsec
SY3514/15	512x8, 700/500nsec
SY4800	2048x8 or 4096x4, 550nsec
SY2316A	2048x8, 550nsec
SY2316B	2048x8, 450nsec, 8K/16K PROM Compatible
SY2332	4096x8, 450nsec, 16K PROM (2716) Compatible
SY2364	• 8192x8, 450nsec, 24 pin

Timekeeping Products

SY5001	CMOS 7 Function, 1 button, 6 digit LCD 12/24 hour and U.S./ European Option
SY5002	CMOS 7 Function, 1 button, 6 digit LED 12/24 hour and U.S./European Option
SY5008	CMOS analog Frequency Divider, 1/2Hz 1/12Hz 20 stepper motor Driver
SY5009A	CMOS Chronograph/Alarm, 6 digit LCD, 12/24 hour and U.S./European Options, Digital Speed Adjust, Event Counter, Taylor/Standard Split, Accumulate

Custom Products

Custom circuit design and processing is an integral part of Synertek's business. Ion implanted N-channel, P-channel and CMOS silicon gate processes all are used for custom circuit manufacturing. Synertek is experienced in interfacing at all levels of development: Logic definition, circuit design, or customer designed tooling. For detailed information contact our sales offices or product marketing in Santa Clara.

Microprocessor Products

SY6500/1	• Single Chip Microprocessor, 40 Pin CPU with 2K bytes of ROM, 64 bytes of RAM and 32 I/O Ports, software compatible with 6502
SY6502	40 Pin CPU, on-chip clock, 65K addressable bytes
SY6503	28 Pin CPU, on-chip clock, 4K addressable bytes
SY6504	28 Pin CPU, one interrupt, on-chip clock, 8K addressable bytes
SY6505	28 Pin CPU, one interrupt, on-chip clock; RDY feature, 4K addressable bytes
SY6506	28 Pin CPU, on-chip clock, 2 phases brought out, 4K addressable bytes
SY6512	40 Pin CPU, external clock, 65K addressable bytes
SY6513	28 Pin CPU, external clock, 4K addressable bytes
SY6514	28 Pin CPU, one interrupt, external clock, 8K addressable bytes
SY6515	28 Pin CPU, one interrupt, external clock; RDY feature, 4K addressable bytes
SY6520	40 Pin Peripheral Interface Adapter Plug replaceable to Motorola's PIA
SY6522	40 Pin VIA—Versatile Interface Adapter—Features of 6520 **Plus:** Two Interval Timers, Latching on I/O Pins, Shift Register for P/S and S/P interface, Interrupt Flag and Enable registers for ease of use
SY6530	40 Pin COMBO, 64 bytes RAM, 1K bytes ROM, 16 I/O channels, Interval Timer
SY6531	• ROM/RAM/I-O/Timer Array, 40 Pin COMBO, 128 bytes RAM, 2K bytes ROM, 16 I/O channels, Interval Timer
SY6532	40 Pin COMBO, 128 bytes RAM, 16 I/O channels, Interval Timer
SY6551	• 40 Pin Asynchronous Communications Chip with on-board programmable baud rate generator

• To be announced.

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Synertek®

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(408) 984-8900 TWX 910-338-0135

SY6500

SY6500 MICROPROCESSORS

The SY6500 Microprocessor Family Concept ----

The SY6500 Series Microprocessors represent the first totally software compatible microprocessor family. This family of products includes a range of software compatible microprocessors which provide a selection of addressable memory range, interrupt input options and on-chip clock osscillators and drivers. All of the microprocessors in the SY6500 group are software compatible within the group and are bus compatible with the M6800 product offering.

The family includes five microprocessors with on-board clock oscillators and drivers and four microprocessors driven by external clocks. The on-chip clock versions are aimed at high performance, low cost applications where single phase inputs, crystal or RC inputs provide the time base. The external clock versions are geared for the multi processor system applications where maximum timing control is mandatory. All versions of the microprocessors are available in 1 MHz and 2 MHz ("A" suffix on product numbers) maximum operating frequencies.

Features of the SY6500 Family

- Single five volt supply
- N channel, silicon gate, depletion load technology
- Eight bit parallel processing
- 56 Instructions
- Decimal and binary arithmetic
- Thirteen addressing modes
- True indexing capability
- Programmable stack pointer
- Variable length stack
- Interrupt capability
- Non-maskable interrupt
- Use with any type or speed memory
- Bi-directional Data Bus
- Instruction decoding and control
- Addressable memory range of up to 65K bytes
- "Ready" input
- Direct memory access capability
- Bus compatible with MC6800
- Choice of external or on-board clocks
- 1MHz and 2MHz operation
- On-the-chip clock options
  * External single clock input
  * RC time base input
  * Crystal time base input
- 40 and 28 pin package versions
- Pipeline architecture

Members of the Family

Microprocessors with On-Board Clock Oscillator

- SY6502
- SY6503
- SY6504
- SY6505
- SY6506

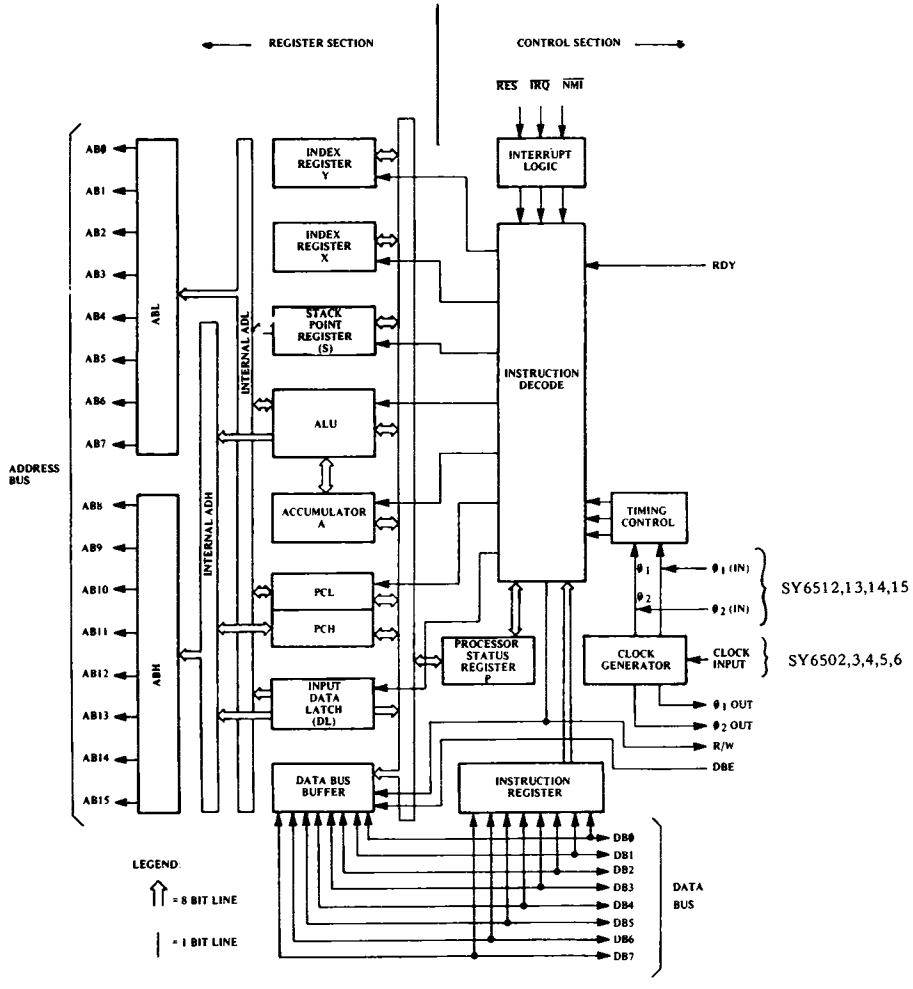
Microprocessors with External Two Phase Clock Input

- SY6512
- SY6513
- SY6514
- SY6515

Comments on the Data Sheet

The data sheet is constructed to review first the basic "Common Characteristics" - those features which are common to the general family of microprocessors. Subsequent to a review of the family characteristics will be sections devoted to each member of the group with specific features of each.

COMMON CHARACTERISTICS



Note: 1. Clock Generator is not included on SY6512,13,14,15

2. Addressing Capability and control options vary with each of the SY6500 Products.

SY6500 Internal Architecture

COMMON CHARACTERISTICS

MAXIMUM RATINGS

RATING	SYMBOL	VALUE	UNIT
SUPPLY VOLTAGE	Vcc	-0.3 to +7.0	Vdc
INPUT VOLTAGE	Vin	-0.3 to +7.0	Vdc
OPERATING TEMPERATURE	T_A	0 to +70	°C
STORAGE TEMPERATURE	T_{STG}	-55 to +150	°C

This device contains input protection against damage due to high static voltages or electric fields; however, precautions should be taken to avoid application of voltages higher than the maximum rating.

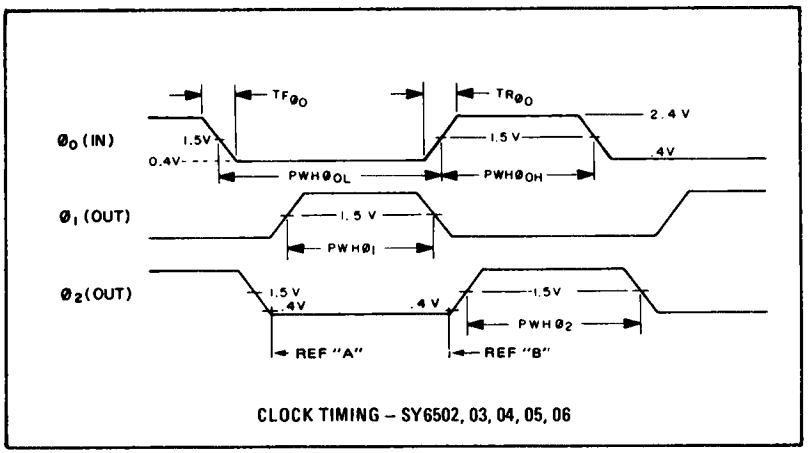
ELECTRICAL CHARACTERISTICS (Vcc = 5.0V ± 5%, Vss = 0, T_A = 25° C)

ϕ_1, ϕ_2 applies to SY6512, 13, 14, 15, $\phi_{o\ (in)}$ applies to SY6502, 03, 04, 05 and 06

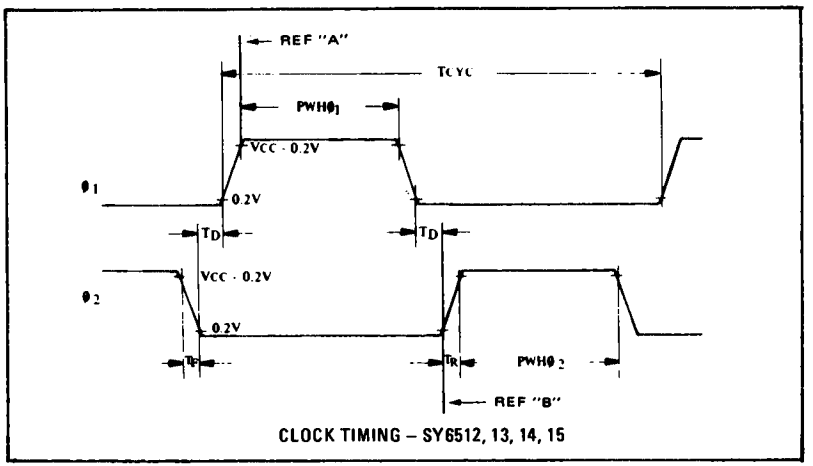
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
Input High Voltage	V_{IH}				Vdc
Logic, $\phi_{o(in)}$		Vss + 2.4	-	Vcc	
ϕ_1, ϕ_2		Vcc - 0.2	-	Vcc + 0.25	
Input Low Voltage	V_{IL}				Vdc
Logic, $\phi_{o(in)}$		Vss - 0.3	-	Vss + 0.4	
ϕ_1, ϕ_2		Vss - 0.3	-	Vss + 0.2	
Input High Threshold Voltage	V_{IHT}				
$\overline{RES}$, $\overline{NMI}$, RDY, $\overline{IRQ}$, Data, S.O.		Vss + 2.0	-	-	Vdc
Input Low Threshold Voltage	V_{ILT}				
$\overline{RES}$, $\overline{NMI}$, RDY, $\overline{IRQ}$, Data, S.O.		-	-	Vss + 0.8	Vdc
Input Leakage Current (V_{in} = 0 to 5.25V, Vcc = 0)	I_{in}				
Logic (Excl. RDY, S.O.)		-	-	2.5	μA
ϕ_1, ϕ_2		-	-	100	μA
$\phi_{o(in)}$		-	-	10.0	μA
Three-State (Off State) Input Current (V_{in} = 0.4 to 2.4V, Vcc = 5.25V)	I_{TSI}				μA
Data Lines		-	-	10	
Output High Voltage (I_{LOAD} = -100μAdc, Vcc = 4.75V)	V_{OH}				
SYNC, Data, A0-A15, R/W		Vss + 2.4	-	-	Vdc
Output Low Voltage (I_{LOAD} = 1.6mAdc, Vcc = 4.75V)	V_{OL}				
SYNC, Data, A0-A15, R/W		-	-	Vss + 0.4	Vdc
Power Dissipation	P_D	-	.25	.70	W
Capacitance (V_{in} = 0, T_A = 25°C, f = 1MHz)	C				pF
Logic	C_{in}	-	-	10	
Data		-	-	15	
A0-A15, R/W, SYNC	C_{out}	-	-	12	
$\phi_{o(in)}$	$C_{\phi_{o(in)}}$	-	-	15	
ϕ_1	C_{ϕ_1}	-	30	50	
ϕ_2	C_{ϕ_2}	-	50	80	

Note: $\overline{IRQ}$ and $\overline{NMI}$ require 3K pull-up resistors.

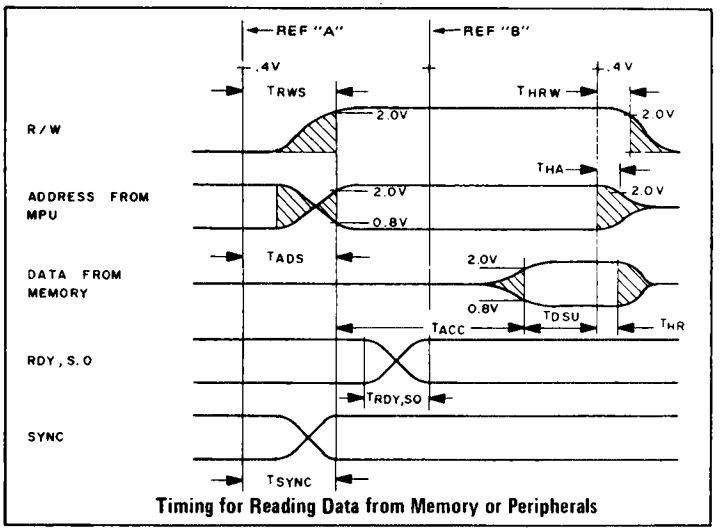
COMMON CHARACTERISTICS



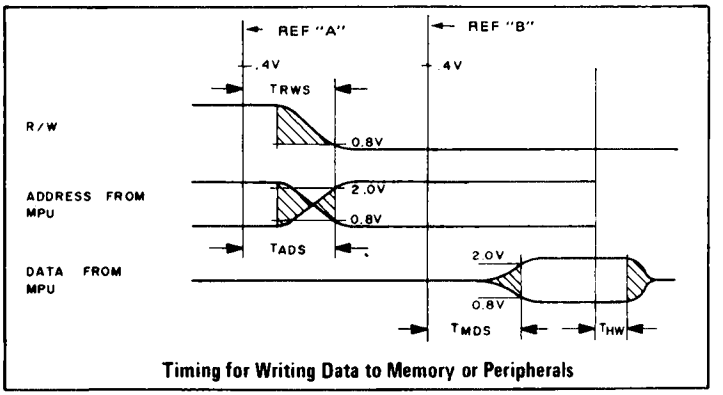
CLOCK TIMING – SY6502, 03, 04, 05, 06



CLOCK TIMING – SY6512, 13, 14, 15



Timing for Reading Data from Memory or Peripherals



Timing for Writing Data to Memory or Peripherals

Note: "REF." means Reference Points on clocks.

1 MHz TIMING

CLOCK TIMING – SY6512, 13, 14, 15

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
Cycle Time	T_{CYC}	1000	---	---	nsec
Clock Pulse Width Ø1 (Measured at Vcc - 0.2v) Ø2	PWH Ø1 PWH Ø2	430 470	---	---	nsec
Fall Time (Measured from 0.2v to Vcc - 0.2v)	T_F	---	---	25	nsec
Delay Time between Clocks (Measured at 0.2v)	T_D	0	---	---	nsec

CLOCK TIMING – SY6502, 03, 04, 05, 06

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNITS
Cycle Time	T_{CYC}	1000	--	--	ns
$\phi_{o(IN)}$ Pulse Width (measured at 1.5V)	$PWH\phi_o$	460	--	520	ns
$\phi_{o(IN)}$ Rise, Fall Time	$TR\phi_o$, $TF\phi_o$	--	--	10	ns
Delay Time Between Clocks (measured at 1.5V)	T_D	5	--	--	ns
$\phi_{1(OUT)}$ Pulse Width (measured at 1.5V)	$PWH\phi_1$	$PWH\phi_{oL}$-20	--	$PWH\phi_{oL}$	ns
$\phi_{2(OUT)}$ Pulse Width (measured at 1.5V)	$PWH\phi_2$	$PWH\phi_{oH}$-40	--	$PWH\phi_{oH}$-10	ns
$\phi_{1(OUT)}$, $\phi_{2(OUT)}$ Rise, Fall Time (measured .8V to 2.0 V) (Load = 30pf + 1 TTL)	T_R, T_F	--	--	25	ns

READ/WRITE TIMING

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNITS
Read/Write Setup Time from SY6500	T_{RWS}	--	100	300	ns
Address Setup Time from SY6500	T_{ADS}	--	100	300	ns
Memory Read Access Time	T_{ACC}	--	--	575	ns
Data Stability Time Period	T_{DSU}	100	--	--	ns
Data Hold Time - Read	T_{HR}	10	--	--	ns
Data Hold Time - Write	T_{HW}	30	60	--	ns
Data Setup Time from SY6500	T_{MDS}	--	150	200	ns
RDY, S.O. Setup Time	T_{RDY}	100	--	--	ns
SYNC Setup Time from SY6500	T_{SYNC}	--	--	350	ns
Address Hold Time	T_{HA}	30	60	--	ns
R/W Hold Time	T_{HRW}	30	60	--	ns

2 MHz TIMING

CLOCK TIMING – SY6512,13,14,15,16

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
Cycle Time	T_{CYC}	500	---	---	nsec
Clock Pulse Width Ø1 (Measured at Vcc - 0.2v) Ø2	PWH Ø1 PWH Ø2	215 235	---	---	nsec
Fall Time (Measured from 0.2v to Vcc - 0.2v)	T_F	---	---	12	nsec
Delay Time between Clocks (Measured at 0.2v)	T_D	0	---	---	nsec

CLOCK TIMING – SY6502, 03, 04, 05, 06

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNITS
Cycle Time	T_{CYC}	500	--	--	ns
$\phi_{o(IN)}$ Pulse Width (measured at 1.5V)	$PWH\phi_o$	240	--	260	ns
$\phi_{o(IN)}$ Rise, Fall Time	$TR\phi_o$, $TF\phi_o$	--	--	10	ns
Delay Time Between Clocks (measured at 1.5V)	T_D	5	--	--	ns
$\phi_{1(OUT)}$ Pulse Width (measured at 1.5V)	$PWH\phi_1$	$PWH\phi_{oL}$-20	--	$PWH\phi_{oL}$	ns
$\phi_{2(OUT)}$ Pulse Width (measured at 1.5V)	$PWH\phi_2$	$PWH\phi_{oH}$-40	--	$PWH\phi_{oH}$-10	ns
$\phi_{1(OUT)}$, $\phi_{2(OUT)}$ Rise, Fall Time (measured .8V to 2.0 V) (Load = 30pf + 1 TTL)	T_R, T_F	--	--	25	ns

READ/WRITE TIMING

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNITS
Read/Write Setup Time from SY6500 A	T_{RWS}	--	100	150	ns
Address Setup Time from SY6500 A	T_{ADS}	--	100	150	ns
Memory Read Access Time	T_{ACC}	--	--	300	ns
Data Stability Time Period	T_{DSU}	50	--	--	ns
Data Hold Time - Read	T_{HR}	10	--	--	ns
Data Hold Time - Write	T_{HW}	30	60	--	ns
Data Setup Time from SY6500 A	T_{MDS}	--	75	100	ns
RDY, S.O. Setup Time	T_{RDY}	50	--	--	ns
SYNC Setup Time from SY6500 A	T_{SYNC}	--	--	175	ns
Address Hold Time	T_{HA}	30	60	--	ns
R/W Hold Time	T_{HRW}	30	60	--	ns

COMMON CHARACTERISTICS

Clocks (ϕ_1, ϕ_2)

The SY651X requires a two phase non-overlapping clock that runs at the Vcc voltage level.

The SY650X clocks are supplied with an internal clock generator. The frequency of these clocks is externally controlled. Details of this feature are discussed in the SY6502 portion of this data sheet.

Address Bus (A_0-A_{15}) (See sections on each micro for respective address lines on those devices.)

These outputs are TTL compatible, capable of driving one standard TTL load and 130pf.

Data Bus (D_0-D_7)

Eight pins are used for the data bus. This is a bi-directional bus, transferring data to and from the device and peripherals. The outputs are tri-state buffers capable of driving one standard TTL load and 130pf.

Data Bus Enable (DBE)

This TTL compatible input allows external control of the tri-state data output buffers and will enable the microprocessor bus driver when in the high state. In normal operation DBE would be driven by the phase two (ϕ_2) clock, thus allowing data output from microprocessor only during ϕ_2. During the read cycle, the data bus drivers are internally disabled, becoming essentially an open circuit. To disable data bus drivers externally, DBE should be held low.

Ready (RDY)

This input signal allows the user to single cycle the microprocessor on all cycles except write cycles. A negative transition to the low state during or coincident with phase one (ϕ_1) will halt the microprocessor with the output address lines reflecting the current address being fetched. This condition will remain through a subsequent phase two (ϕ_2) in which the Ready signal is low. This feature allows microprocessor interfacing with low speed PROMS as well as fast (max. 2 cycle) Direct Memory Access (DMA). If Ready is low during a write cycle, it is ignored until the following read operation.

Interrupt Request ($\overline{IRQ}$)

This TTL level input requests that an interrupt sequence begin within the microprocessor. The microprocessor will complete the current instruction being executed before recognizing the request. At that time, the interrupt mask bit in the Status Code Register will be examined. If the interrupt mask flag is not set, the microprocessor will begin an interrupt sequence. The Program Counter and Processor Status Register are stored in the stack. The microprocessor will then set the interrupt mask flag high so that no further interrupts may occur. At the end of this cycle, the program counter low will be loaded from address FFFE, and program counter high from location FFFF, therefore transferring program control to the memory vector located at these addresses. The RDY signal must be in the high state for any interrupt to be recognized. A 3KΩ external resistor should be used for proper wire-OR operation.

Non-Maskable Interrupt ($\overline{NMI}$)

A negative going edge on this input requests that a non-maskable interrupt sequence be generated within the microprocessor.

$\overline{NMI}$ is an unconditional interrupt. Following completion of the current instruction, the sequence of operations defined for $\overline{IRQ}$ will be performed, regardless of the state interrupt mask flag. The vector address loaded into the program counter, low and high, are locations FFFA and FFFB respectively, thereby transferring program control to the memory vector located at these addresses. The instructions loaded at these locations cause the microprocessor to branch to a non-maskable interrupt routine in memory.

$\overline{NMI}$ also requires an external 3KΩ register to Vcc for proper wire-OR operations.

Inputs $\overline{IRQ}$ and $\overline{NMI}$ are hardware interrupts lines that are sampled during ϕ_2 (phase 2) and will begin the appropriate interrupt routine on the ϕ_1 (phase 1) following the completion of the current instruction.

Set Overflow Flag (S.O.)

A NEGATIVE going edge on this input sets the overflow bit in the Status Code Register. This signal is sampled on the trailing edge of ϕ_1.

SYNC

This output line is provided to identify those cycles in which the microprocessor is doing an OP CODE fetch. The SYNC line goes high during ϕ_1 of an OP CODE fetch and stays high for the remainder of that cycle. If the RDY line is pulled low during the ϕ_1 clock pulse in which SYNC went high, the processor will stop in its current state and will remain in the state until the RDY line goes high. In this manner, the SYNC signal can be used to control RDY to cause single instruction execution.

Reset

This input is used to reset or start the microprocessor from a power down condition. During the time that this line is held low, writing to or from the microprocessor is inhibited. When a positive edge is detected on the input, the microprocessor will immediately begin the reset sequence.

After a system initialization time of six clock cycles, the mask interrupt flag will be set and the microprocessor will load the program counter from the memory vector locations FFFC and FFFD. This is the start location for program control.

After Vcc reaches 4.75 volts in a power up routine, reset must be held low for at least two clock cycles. At this time the R/W and (SYNC) signal will become valid.

When the reset signal goes high following these two clock cycles, the microprocessor will proceed with the normal reset procedure detailed above.

COMMON CHARACTERISTICS

INSTRUCTION SET – ALPHABETIC SEQUENCE

ADC	Add Memory to Accumulator with Carry
AND	"AND" Memory with Accumulator
ASL	Shift left One Bit (Memory or Accumulator)
BCC	Branch on Carry Clear
BCS	Branch on Carry Set
BEQ	Branch on Result Zero
BIT	Test Bits in Memory with Accumulator
BMI	Branch on Result Minus
BNE	Branch on Result not Zero
BPL	Branch on Result Plus
BRK	Force Break
BVC	Branch on Overflow Clear
BVS	Branch on Overflow Set
CLC	Clear Carry Flag
CLD	Clear Decimal Mode
CLI	Clear Interrupt Disable Bit
CLV	Clear Overflow Flag
CMP	Compare Memory and Accumulator
CPX	Compare Memory and Index X
CPY	Compare Memory and Index Y
DEC	Decrement Memory by One
DEX	Decrement Index X by One
DEY	Decrement Index Y by One
EOR	"Exclusive-or" Memory with Accumulator
INC	Increment Memory by One
INX	Increment Index X by One
INY	Increment Index Y by One
JMP	Jump to New Location
JSR	Jump to New Location Saving Return Address
LDA	Load Accumulator with Memory
LDX	Load Index X with Memory
LDY	Load Index Y with Memory
LSR	Shift One Bit Right (Memory or Accumulator)
NOP	No Operation
ORA	"OR Memory with Accumulator
PHA	Push Accumulator on Stack
PHP	Push Processor Status on Stack
PLA	Pull Accumulator from Stack
PLP	Pull Processor Status from Stack
ROL	Rotate One Bit Left (Memory or Accumulator)
ROR	Rotate One Bit Right (Memory or Accumulator)
RTI	Return from Interrupt
RTS	Return from Subroutine
SBC	Subtract Memory from Accumulator with Borrow
SEC	Set Carry Flag
SED	Set Decimal Mode
SEI	Set Interrupt Disable Status
STA	Store Accumulator in Memory
STX	Store Index X in Memory
STY	Store Index Y in Memory
TAX	Transfer Accumulator to Index X
TAY	Transfer Accumulator to Index Y
TSX	Transfer Stack Pointer to Index X
TXA	Transfer Index X to Accumulator
TXS	Transfer Index X to Stack Pointer
TYA	Transfer Index Y to Accumulator

ADDRESSING MODES

ACCUMULATOR ADDRESSING - This form of addressing is represented with a one byte instruction, implying an operation on the accumulator.

IMMEDIATE ADDRESSING - In immediate addressing, the operand is contained in the second byte of the instruction, with no further memory addressing required.

ABSOLUTE ADDRESSING - In absolute addressing, the second byte of the instruction specifies the eight low order bits of the effective address while the third byte specifies the eight high order bits. Thus, the absolute addressing mode allows access to the entire 65K bytes of addressable memory.

ZERO PAGE ADDRESSING - The zero page instructions allow for shorter code and execution times by only fetching the second byte of the instruction and assuming a zero high address byte. Careful use of the zero page can result in significant increase in code efficiency.

INDEXED ZERO PAGE ADDRESSING - (X, Y indexing) - This form of addressing is used in conjunction with the index register and is referred to as "Zero Page, X" or "Zero Page, Y". The effective address is calculated by adding the second byte to the contents of the index register. Since this is a form of "Zero Page" addressing, the content of the second byte references a location in page zero. Additionally due to the "Zero Page" addressing nature of this mode, no carry is added to the high order 8 bits of memory and crossing of page boundaries does not occur.

INDEXED ABSOLUTE ADDRESSING - (X, Y indexing) - This form of addressing is used in conjunction with X and Y index register and is referred to as "Absolute, X", and "Absolute, Y". The effective address is formed by adding the contents of X or Y to the address contained in the second and third bytes of the instruction. This mode allows the index register to contain the index or count value and the instruction to contain the base address. This type of indexing allows any location referencing and the index to modify multiple fields resulting in reduced coding and execution time.

IMPLIED ADDRESSING - In the implied addressing mode, the address containing the operand is implicitly stated in the operation code of the instruction.

RELATIVE ADDRESSING - Relative addressing is used only with branch instructions and establishes a destination for the conditional branch.

The second byte of the instruction becomes the operand which is an "Offset" added to the contents of the lower eight bits of the program counter when the counter is set at the next instruction. The range of the offset is -128 to +127 bytes from the next instruction.

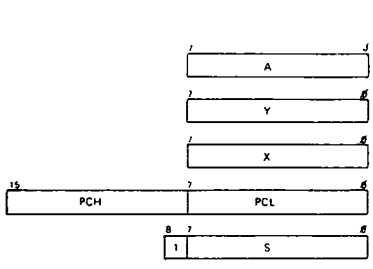
INDEXED INDIRECT ADDRESSING - In indexed indirect addressing (referred to as (Indirect,X)), the second byte of the instruction is added to the contents of the X index register, discarding the carry. The result of this addition points to a memory location on page zero whose contents is the low order eight bits of the effective address. The next memory location in page zero contains the high order eight bits of the effective address. Both memory locations specifying the high and low order bytes of the effective address must be in page zero.

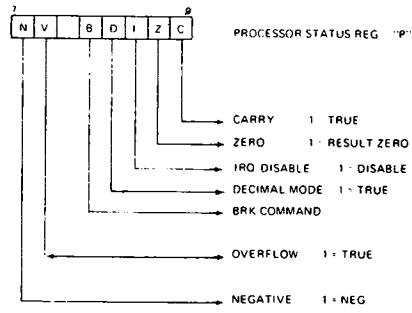
INDIRECT INDEXED ADDRESSING - In indirect indexed addressing (referred to as (Indirect),Y), the second byte of the instruction points to a memory location in page zero. The contents of this memory location is added to the contents of the Y index register, the result being the low order eight bits of the effective address. The carry from this addition is added to the contents of the next page zero memory location, the result being the high order eight bits of the effective address.

ABSOLUTE INDIRECT - The second byte of the instruction contains the low order eight bits of a memory location. The high order eight bits of that memory location is contained in the third byte of the instruction. The contents of the fully specified memory location is the low order byte of the effective address. The next memory location contains the high order byte of the effective address which is loaded into the sixteen bits of the program counter.

COMMON CHARACTERISTICS

PROGRAMMING MODEL





INSTRUCTION SET – OP CODES, Execution Time, Memory Requirements

INSTRUCTIONS		IMMEDIATE			ABSOLUTE			ZERO PAGE			ACCUM.			IMPLIED			(IND,X)			(IND),Y			Z,PAGE,X			ABS,X			ABS,Y			RELATIVE			INDIRECT			Z,PAGE,Y			CONDITION CODES					
MNEMONIC	OPERATION	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	N	Z	C	I	D	V
ADC	A+M+C → A (4) (1)	69	2	2	6D	4	3	65	3	2							61	6	2	71	5	2	75	4	2	7D	4	3	79	4	3										✓	✓	✓			✓
AND	A∧M → A (1)	29	2	2	2D	4	3	25	3	2							21	6	2	31	5	2	35	4	2	3D	4	3	39	4	3										✓	✓				
ASL	C ← 7 ← 0 ← C				0E	6	3	06	5	2	0A	2	1										16	6	2	1E	7	3													✓	✓	✓	-	-	-
BCC	BRANCH ON C = 0 (2)																															90	2	2							-	-	-	-	-	-
BCS	BRANCH ON C = 1 (2)																															B0	2	2							-	-	-	-	-	-
BEQ	BRANCH ON Z = 1 (2)																															F0	2	2							-	-	-	-	-	-
BIT	A∧M				2C	4	3	24	3	2																															M7	✓				M6
BMI	BRANCH ON N = 1 (2)																															30	2	2							-	-	-	-	-	-
BNE	BRANCH ON Z = 0 (2)																															D0	2	2							-	-	-	-	-	-
BPL	BRANCH ON N = 0 (2)																															10	2	2							-	-	-	-	-	-
BRK	(See Fig. 11)													00	7	1																									-	-	-	1	-	-
BVC	BRANCH ON V = 0 (2)																															50	2	2							-	-	-	-	-	-
BVS	BRANCH ON V = 1 (2)																															70	2	2							-	-	-	-	-	-
CLC	0 → C													18	2	1																									-	-	0	-	-	-
CLD	0 → D													D8	2	1																									-	-	-	-	0	-
CLI	0 → I													58	2	1																									-	-	-	0	-	-
CLV	0 → V													B8	2	1																									-	-	-	-	-	0
CMP	A − M	C9	2	2	CD	4	3	C5	3	2							C1	6	2	D1	5	2	D5	4	2	DD	4	3	D9	4	3										✓	✓	✓			
CPX	X − M	E0	2	2	EC	4	3	E4	3	2																															✓	✓	✓			
CPY	Y − M	C0	2	2	CC	4	3	C4	3	2																															✓	✓	✓			
DEC	M − 1 → M				CE	6	3	C6	5	2													D6	6	2	DE	7	3													✓	✓				
DEX	X − 1 → X													CA	2	1																									✓	✓				
DEY	Y − 1 → Y													88	2	1																									✓	✓				
EOR	A ⊻ M → A (1)	49	2	2	4D	4	3	45	3	2							41	6	2	51	5	2	55	4	2	5D	4	3	59	4	3										✓	✓				
INC	M + 1 → M				EE	6	3	E6	5	2													F6	6	2	FE	7	3													✓	✓				
INX	X + 1 → X													E8	2	1																									✓	✓				
INY	Y + 1 → Y													C8	2	1																									✓	✓				
JMP	JUMP TO NEW LOC				4C	3	3																												6C	5	3							
JSR	(See Fig. 2) JUMP SUB				20	6	3																																						
LDA	M → A (1)	A9	2	2	AD	4	3	A5	3	2							A1	6	2	B1	5	2	B5	4	2	BD	4	3	B9	4	3										✓	✓				

MNEMONIC	OPERATION	IMMEDIATE			ABSOLUTE			ZERO PAGE			ACCUM.			IMPLIED			(IND,X)			(IND),Y			Z,PAGE,X			ABS,X			ABS,Y			RELATIVE			INDIRECT			Z,PAGE,Y			CONDITION CODES					
		OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	N	Z	C	I	D	V
LDX	M → X (1)	A2	2	2	AE	4	3	A6	3	2																			BE	4	3										✓	✓				
LDY	M → Y (1)	A0	2	2	AC	4	3	A4	3	2													B4	4	2	BC	4	3													✓	✓				
LSR	0 → 7 → 0 → C				4E	6	3	46	5	2	4A	2	1										56	6	2	5E	7	3													0	✓	✓			
NOP	NO OPERATION													EA	2	1																														
ORA	A ∨ M → A	09	2	2	0D	4	3	05	3	2							01	6	2	11	5	2	15	4	2	1D	4	3	19	4	3										✓	✓				
PHA	A → M7 S − 1 → S													48	3	1																														
PHP	P → M7 S − 1 → S													08	3	1																														
PLA	S + 1 → S M7 → A													68	4	1																										✓	✓				
PLP	S + 1 → S M7 → P													28	4	1																										(RESTORED)					
ROL	C 7 0				2E	6	3	26	5	2	2A	2	1										36	6	2	3E	7	3													✓	✓	✓			
ROR	C 7 0				6E	6	3	66	5	2	6A	2	1										76	6	2	7E	7	3													✓	✓	✓			
RTI	(See Fig. 11) RTRN INT													40	6	1																										(RESTORED)					
RTS	(See Fig. 2) RTRN SUB													60	6	1																														
SBC	A − M − C → A (1)	E9	2	2	ED	4	3	E5	3	2							E1	6	2	F1	5	2	F5	4	2	FD	4	3	F9	4	3										✓	✓	✓ (3)			✓
SEC	1 → C													38	2	1																											1			
SED	1 → D													F8	2	1																												1		
SEI	1 → I													78	2	1																												1		
STA	A → M				8D	4	3	85	3	2							81	6	2	91	6	2	95	4	2	9D	5	3	99	5	3														
STX	X → M				8E	4	3	86	3	2																																				
STY	Y → M				8C	4	3	84	3	2													94	4	2																				
TAX	A → X													AA	2	1																										✓	✓				
TAY	A → Y													A8	2	1																										✓	✓				
TSX	S → X													BA	2	1																										✓	✓				
TXA	X → A													8A	2	1																										✓	✓				
TXS	X → S													9A	2	1																														
TYA	Y → A													98	2	1																										✓	✓				

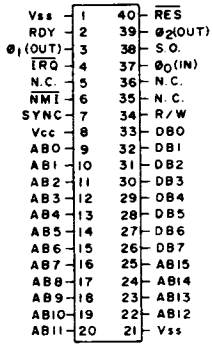
(1) ADD 1 TO N IF PAGE BOUNDRY IS CROSSED
(2) ADD 1 TO N IF BRANCH OCCURS TO SAME PAGE
ADD 2 TO N IF BRANCH OCCURS TO DIFFERENT PAGE
(3) CARRY NOT BORROW
(4) IF IN DECIMAL MODE Z FLAG IS INVALID
ACCUMULATOR MUST BE CHECKED FOR ZERO RESULT

X INDEX X
Y INDEX Y
A ACCUMULATOR
M MEMORY PER EFFECTIVE ADDRESS
M7 MEMORY PER EFFECTIVE ADDRESS
M6 MEMORY PER EFFECTIVE ADDRESS

ADD
SUBTRACT
MODIFIED
NOT MODIFIED
AND
OR
EXCLUSIVE OR

N NO CYCLES
NO BYTES

SY6502 – 40 Pin Package

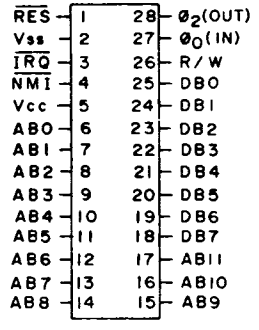


SY6502

* 65K Addressable Bytes of Memory
* IRQ Interrupt * NMI Interrupt
* On-the-chip Clock
  - ✓ TTL Level Single Phase Input
  - ✓ RC Time Base Input
  - ✓ Crystal Time Base Input
* SYNC Signal
  (can be used for single instruction execution)
* RDY Signal
  (can be used for single cycle execution)
* Two Phase Output Clock for Timing of Support Chips

Features of SY6502

SY6503 – 28 Pin Package

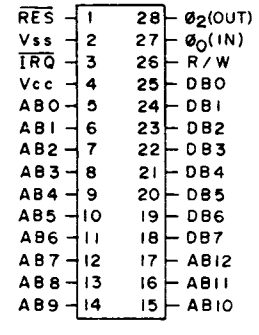


SY6503

* 4K Addressable Bytes of Memory (AB00-AB11)
* On-the-chip Clock
* IRQ Interrupt
* NMI Interrupt
* 8 Bit Bi-Directional Data Bus

Features of SY6503

SY6504 – 28 Pin Package

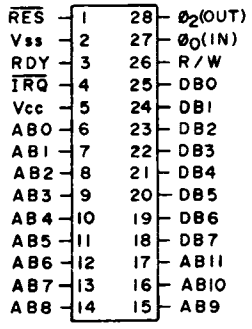


SY6504

* 8K Addressable Bytes of Memory (AB00-AB12)
* On-the-chip Clock
* IRQ Interrupt
* 8 Bit Bi-Directional Data Bus

Features of SY6504

SY6505 – 28 Pin Package

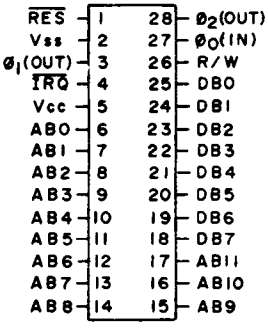


SY6505

* 4K Addressable Bytes of Memory (AB00-AB11)
* On-the-chip Clock
* $\overline{IRQ}$ Interrupt
* RDY Signal
* 8 Bit Bi-Directional Data Bus

Features of SY6505

SY6506 – 28 Pin Package

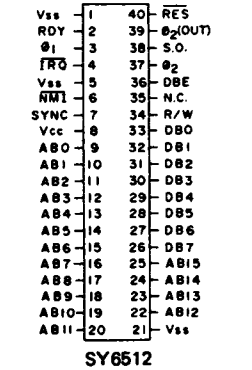


SY6506

* 4K Addressable Bytes of Memory (AB00-AB11)
* On-the-chip Clock
* $\overline{IRQ}$ Interrupt
* Two phases off
* 8 Bit Bi-Directional Data Bus

Features of SY6506

SY6512 – 40 Pin Package

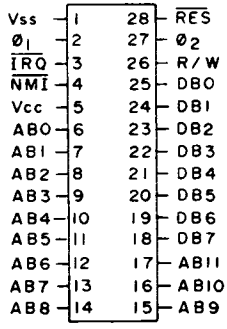


SY6512

* 65K Addressable Bytes of Memory
* $\overline{IRQ}$ Interrupt
* $\overline{NMI}$ Interrupt
* RDY Signal
* 8 Bit Bi-Directional Data Bus
* SYNC Signal
* Two phase input
* Data Bus Enable

Features of SY6512

SY6513 – 28 Pin Package

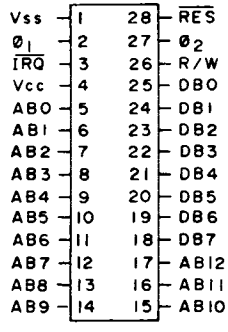


SY6513

* 4K Addressable Bytes of Memory (AB00-AB11)
* Two phase clock input
* $\overline{IRQ}$ Interrupt
* $\overline{NMI}$ Interrupt
* 8 Bit Bi-Directional Data Bus

Features of SY6513

SY6514 – 28 Pin Package

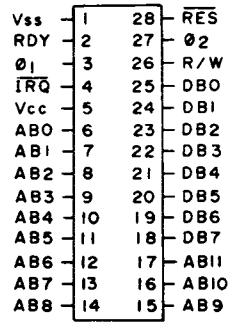


SY6514

* 8K Addressable Bytes of Memory (AB00-AB12)
* Two phase clock input
* $\overline{IRQ}$ Interrupt
* 8 Bit Bi-Directional Data Bus

Features of SY6514

SY6515 – 28 Pin Package



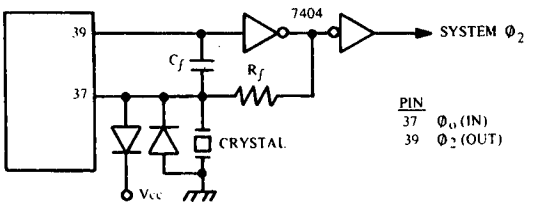
SY6515

* 4K Addressable Bytes of Memory (AB00-AB11)
* Two phase clock input
* $\overline{IRQ}$ Interrupt
* 8 Bit Bi-Directional Data Bus

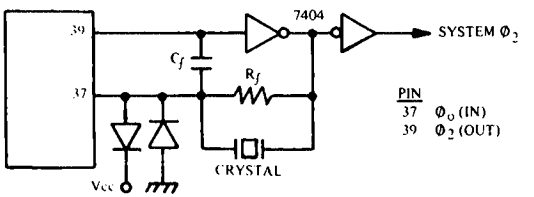
Features of SY6515

TIME BASE GENERATION OF INPUT CLOCK

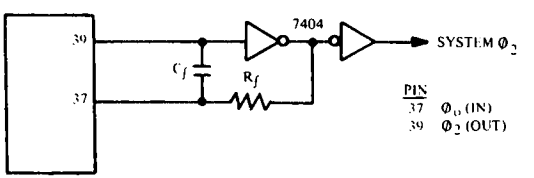
SY6502



SY6502 Parallel Mode Crystal Controlled Oscillator

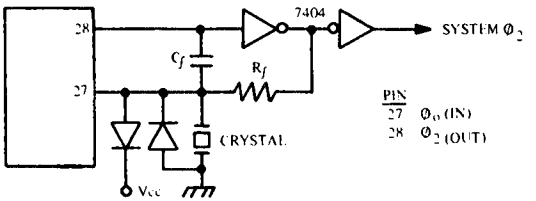


SY6502 Series Mode Crystal Controlled Oscillator

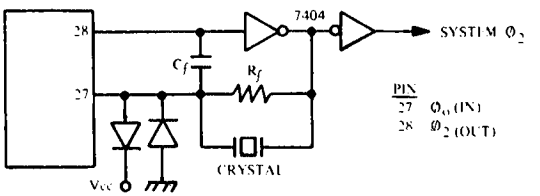


SY6502 Time Base Generator – RC Network

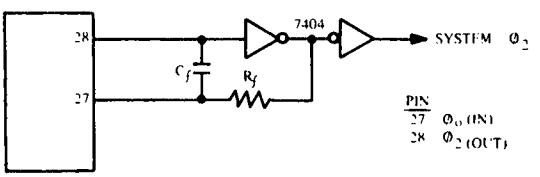
SY6503, SY6504, SY6505, SY6506



SY6503,4,5,6 Parallel Mode Crystal Controlled Oscillator



SY6503,4,5,6 Series Mode Crystal Controlled Oscillator



SY6503,4,5,6 Time Base Generation RC Network

APPENDIX H

SY6522 DATA SHEET

Synertek®

3050 Coronado Drive, Santa Clara, CA. 95051
(408) 984-8900 TWX 910-338-0135

SY6522

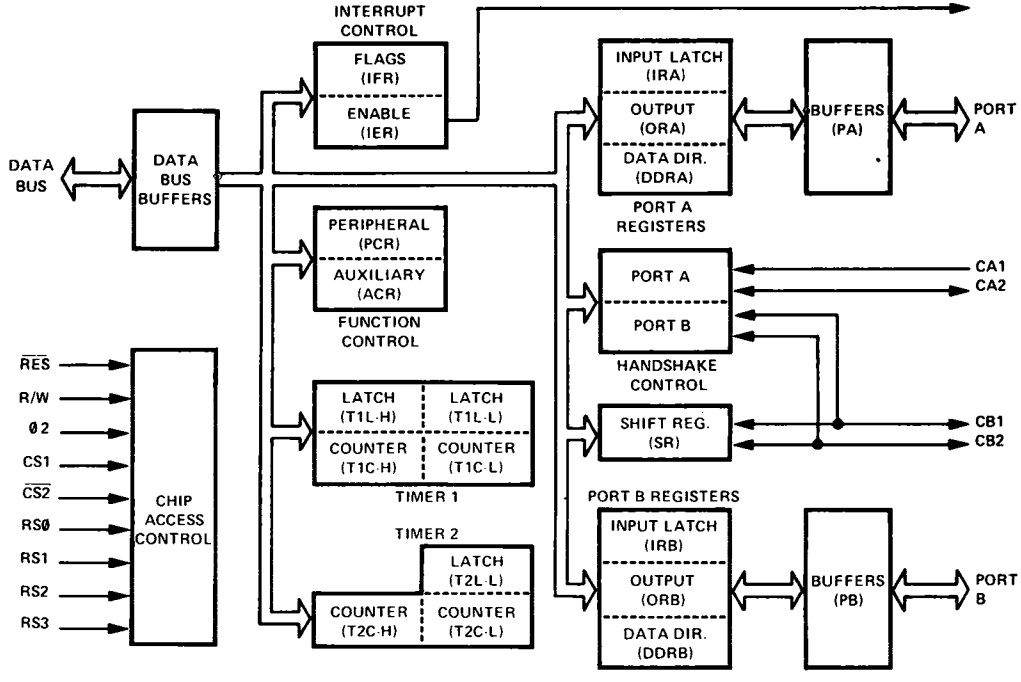
SY6522 (VERSATILE INTERFACE ADAPTER)

The SY6522 Versatile Interface Adapter (VIA) provides all of the capability of the SY6520. In addition, this device contains a pair of very powerful interval timers, a serial-to-parallel/parallel-to-serial shift register and input data latching on the peripheral ports. Expanded handshaking capability allows control of bi-directional data transfers between VIA's in multiple processor systems.

Control of peripheral devices is handled primarily through two 8-bit bi-directional ports. Each of these lines can be programmed to act as either an input or an output. Also, several peripheral I/O lines can be controlled directly from the interval timers for generating programmable frequency square waves and for counting externally generated pulses. To facilitate control of the many powerful features of this chip, the internal registers have been organized into an interrupt flag register, an interrupt enable register and a pair of function control registers.

- Very powerful expansion of basic SY6520 capability.
- N channel, depletion load technology, single +5V Supply.
- Completely static and TTL compatible.
- CMOS compatible peripheral control lines.
- Expanded "handshake" capability allows very positive control of data transfers between processor and peripheral devices.

Figure 1. SY6522 BLOCK DIAGRAM



MAXIMUM RATINGS

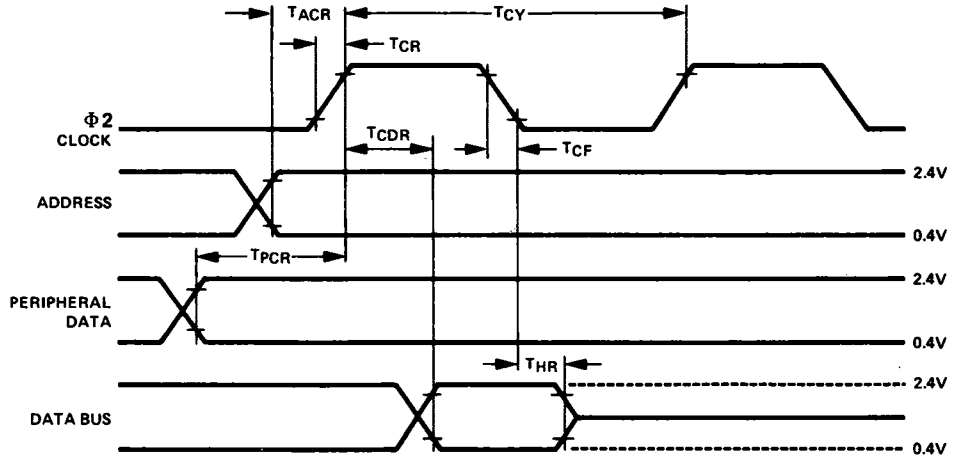
	Symbol	Value	Unit
Supply Voltage	Vcc	-0.3 to +7.0	Vdc
Input Voltage	Vin	-0.3 to +7.0	Vdc
Operating Temperature Range	T_A	0 to +70	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C

This device contains circuitry to protect the inputs against damage due to high static voltages. However, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages.

Electrical Characteristics (V_{CC} = 5.0V ±5%, V_{SS} = 0, T_A = 0°C to 70°C unless otherwise noted)

CHARACTERISTIC	SYMBOL	MIN	TYP	MAX	UNIT
Input high voltage (normal operation)	V_{IH}	+2.4	–	Vcc	Vdc
Input Low Voltage (normal operation)	V_{IL}	-0.3	–	+0.4	Vdc
Input Leakage current - V_{IN} = 0 to 5 Vdc R/W, $\overline{RES}$, RS0, RS1, RS2, RS3, CS1, $\overline{CS2}$, CA1, Φ2	I_{IN}	–	±1.0	±2.5	μAdc
Off-state input current - V_{IN} = .4 to 2.4 V Vcc = Max, D0 to D7	I_{TSI}	–	±2.0	±10	μAdc
Input high current - V_{IH} = 2.4 V PA0 - PA7, CA2, PB0 - PB7, CB1, CB2	I_{IH}	-100	-250	–	μAdc
Input low current - V_{IL} = 0.4 Vdc PA0 - PA7, CA2, PB0 - PB7, CB1, CB2	I_{IL}	–	-1.0	-1.6	mAdc
Output high voltage Vcc = min, I_{load} = -100 μAdc PA0 - PA7, CA2, PB0 -PB7, CB1, CB2	V_{OH}	2.4	–	–	Vdc
Output low voltage Vcc = min, I_{load} = 1.6 mAdc	V_{OL}	–	–	+0.4	Vdc
Output high current (sourcing) V_{OH} = 2.4 V V_{OH} = 1.5 V, PB0 - PB7, CB1, CB2	I_{OH}	 -100 -3.0	 -1000 -5.0	 – –	 μAdc mAdc
Output low current (sinking) V_{OL} = 0.4 Vdc	I_{OL}	1.6	–	–	mAdc
Output leakage current (off state) $\overline{IRQ}$	I_{off}	–	1.0	10	μAdc
Input capacitance - T_A = 25°C, f = 1 Mhz R/W, $\overline{RES}$, RS0, RS1, RS2, RS3, CS1, $\overline{CS2}$ DO - D7, PA0 - PA7, CA1, CA2, PB0 - PB7, CB1, CB2 Φ2 input	C_{in}	 – –	 – –	 7.0 10	 pF pF
		–	–	20	pF
Output capacitance - T_A = 25°C, f = 1 Mhz	C_{out}	–	–	10	pF
Power dissipation	P_d	–	–	1000	MW

Figure 2. READ TIMING CHARACTERISTICS



DYNAMIC CHARACTERISTICS

Read Timing Characteristics (Figure 2, loading 130 pF and one TTL load)

Characteristic	Symbol	Min	Typ	Max	Unit
Cycle time	T_{CY}	1	–	50	μs
Delay time, address valid to clock positive transition	T_{ACR}	180	–	–	nS
Delay time, clock positive transition to data valid on bus	T_{CDR}	–	–	395	nS
Peripheral data setup time	T_{PCR}	300	–	–	nS
Data bus hold time	T_{HR}	10	–	–	nS
Rise and fall time for clock input	T_{CR} T_{CF}	–	–	25	nS

Write Timing Characteristics (Figure 3)

Characteristic	Symbol	Min	Typ	Max	Unit
Cycle Time	T_{CY}	1	–	50	μS
Enable pulse width	T_C	0.47	–	25	μS
Delay time, address valid to clock positive transition	T_{ACW}	180	–	–	nS
Delay time, data valid to clock negative transition	T_{DCW}	300	–	–	nS
Delay time, read/write negative transition to clock positive transition	T_{WCW}	180	–	–	nS
Data bus hold time	T_{HW}	10	–	–	nS
Delay time, Enable negative transition to peripheral data valid	T_{CPW}	–	–	1.0	μS
Delay time, clock negative transition to peripheral data valid CMOS (Vcc - 30%)	T_{CMOS}	–	–	2.0	μS

Figure 3. WRITE TIMING CHARACTERISTICS

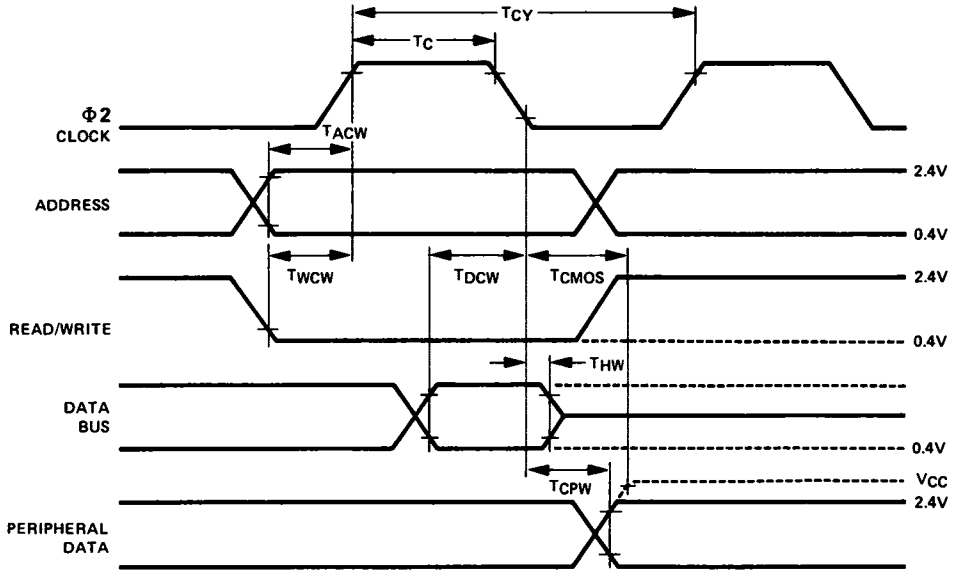
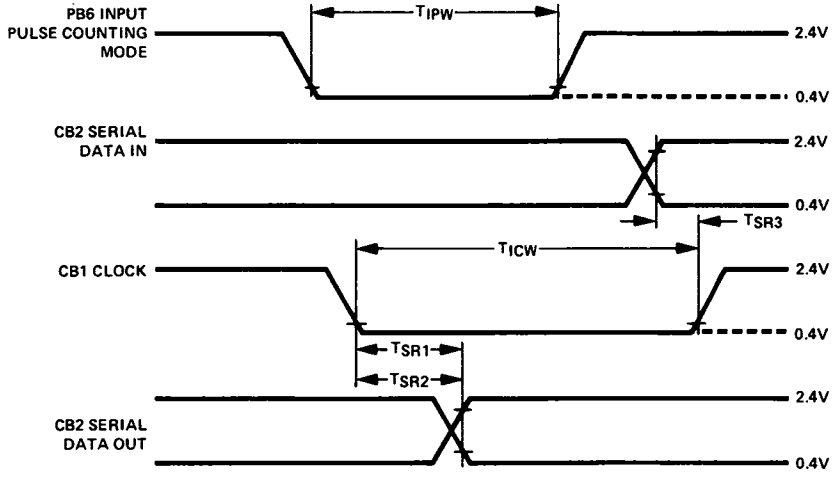


Figure 4. I/O TIMING CHARACTERISTICS



PERIPHERAL INTERFACE CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Rise and fall time for CA1, CB1, CA2, and CB2 input signals.	T_{RF}	–	–	1.0	μS
Delay time, clock negative transition to CA2 negative transition (read handshake or pulse mode).	T_{CA2}	–	–	1.0	μS
Delay time, clock negative transition to CA2 positive transition (pulse mode).	T_{RS1}	–	–	1.0	μS
Delay time, CA1 active transition to CA2 positive transition (handshake mode).	T_{RS2}	–	–	2.0	μS
Delay time, clock positive transition to CA2 or CB2 negative transition (write handshake).	T_{WHS}	–	–	1.0	μS
Delay time, peripheral data valid to CB2 negative transition.	T_{DC}	0	–	1.5	μS
Delay time, clock positive transition to CA2 or CB2 positive transition (pulse mode).	T_{RS3}	–	–	1.0	μS
Delay time, CB1 active transition to CA2 or CB2 positive transition (handshake mode).	T_{RS4}	–	–	2.0	μS
Delay time, peripheral data valid to CA1 or CB1 active transition (input latching).	T_{IL}	300	–	–	nS
Delay time, CB1 negative transition to CB2 data valid (internal SR clock, shift out).	T_{SR1}	–	–	300	nS
Delay time, negative transition of CB1 input clock to CB2 data valid (external clock, shift out).	T_{SR2}	–	–	300	nS
Delay time, CB2 data valid to positive transition of CB1 clock (shift in, internal or external clock)	T_{SR3}	–	–	300	nS
Pulse Width - PB6 Input Pulse	T_{IPW}	2	–	–	μS
Pulse Width - CB1 Input Clock	T_{ICW}	2	–	–	μS
Pulse Spacing - PB6 Input Pulse	I_{IPS}	2	–	–	μS
Pulse Spacing - CB1 Input Pulse	I_{ICS}	2	–	–	μS

PROCESSOR INTERFACE

This section contains a description of the buses and control lines which are used to interface the SY6522 to the system processor. Electrical parameters associated with this interface are specified elsewhere in this document.

1. Phase Two Clock (Φ2)

Data transfers between the SY6522 and the system processor take place only while the Phase Two Clock is high. In addition, Φ2 acts as the time base for the various timers, shift registers, etc. on the chip.

2. Chip Select Lines (CS1, $\overline{CS2}$)

The two chip select inputs are normally connected to processor address lines either directly or through decoding. The selected SY6522 register will be accessed when CS1 is high and $\overline{CS2}$ is low.

3. Register Select Lines (RS0, RS1, RS2, RS3)

The four Register select lines are normally connected to the processor address bus lines to allow the processor to select the internal SY6522 register which is to be accessed. The sixteen possible combinations access the registers as follows:

RS3	RS2	RS1	RS0	REGISTER	REMARKS
L	L	L	L	ORB, IRB	
L	L	L	H	ORA, IRA	Controls Handshake
L	L	H	L	DDRB	
L	L	H	H	DDRA	
L	H	L	L	T1L-L	Write Latch Read Counter
L	H	L	H	T1C-H	Trigger T1L-L/ T1C-L Transfer
L	H	H	L	T1L-L	
L	H	H	H	T1L-H	
H	L	L	L	T2L-L T2C-L	Write Latch Read Counter
H	L	L	H	T2C-H	Triggers T2L-L/ T2C-L Transfer
H	L	H	L	SR	
H	L	H	H	ACR	
H	H	L	L	PCR	
H	H	L	H	IFR	
H	H	H	L	IER	
H	H	H	H	ORA	No Effect on Handshake

NOTE: $L \leqslant 0.4V$
$H \geqslant 2.4V$

4. Read/Write Line (R/W)

The direction of the data transfers between the SY6522 and the system processor is controlled by the R/W line. If R/W is low, data will be transferred out of the processor into the selected SY6522 register (write operation). If R/W is high and the chip is selected, data will be transferred out of the SY6522 (read operation).

5. Data Bus (DB0 - DB7)

The 8 bi-directional data bus lines are used to transfer data between the SY6522 and the system processor. The internal drivers will remain in the high-impedance state except when the chip is selected (CS1=HI, $\overline{CS2}$=LO), Read/Write is high and the Phase Two Clock is high. At this time, the contents of the selected register are placed on the data bus. When the chip is selected, with Read/Write low and Φ2 = 1, the data on the data bus will be transferred into the selected SY6522 register.

6. Reset ($\overline{RES}$)

The reset input clears all internal registers to logic 0 (except T1, T2 and SR). This places all peripheral interface lines in the input state, disables the timers, shift register, etc. and disables interrupting from the chip.

7. Interrupt Request ($\overline{IRQ}$)

The Interrupt Request output goes low whenever an internal interrupt flag is set and the corresponding interrupt enable bit is a logic 1. This output is "open-drain" to allow the interrupt request signal to be "wire-or'ed" with other equivalent signals in the system.

PERIPHERAL INTERFACE

This section contains a brief description of the buses and control lines which are used to drive peripheral devices under control of the internal SY6522 registers.

1. Peripheral A Port (PA0 - PA7)

The Peripheral A port consists of 8 lines which can be individually programmed to act as an input or an output under control of a Data Direction Register. The polarity of output pins is controlled by the Output Register and input data can be latched into an internal register under control of the CA line. All of these modes of operation are controlled by the system processor through the internal control register. These lines will present one standard TTL load in the input mode and will drive one standard TTL load in the output mode.

2. Peripheral A Control Lines (CA1, CA2)

The two peripheral A control lines act as interrupt inputs or as handshake outputs. Each line controls an internal interrupt flag with a corresponding interrupt enable bit. In addition, CA1 controls the latching of data for Peripheral A Port Input lines. The various modes of operation are controlled by the system processor through the internal control registers. CA1 is a high-impedance input only while CA2 represents one standard TTL load in the input mode. CA2 will drive one standard TTL load in the output mode.

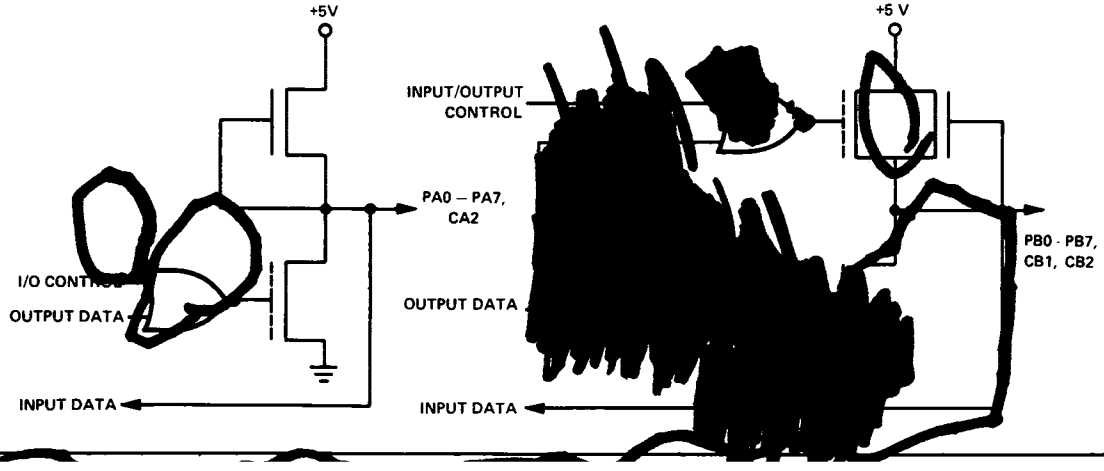
3. Peripheral B Port (PB0 - PB7)

The Peripheral B Port consists of 8 bi-directional lines which are controlled by an output register and a data direction register in much the same manner as the PA port. In addition, the polarity of the PB7 output signal can be controlled by one of the interval timers while the second timer can be programmed to count pulses on the PB6 pin. These lines represent one standard TTL load in the input mode and will drive one standard TTL load in the output mode. In addition, they are capable of sourcing 3.0 ma at 1.5 VDC in the output mode to allow the outputs to directly drive Darlington transistor switches.

4. Peripheral B Control Lines (CB1, CB2)

The Peripheral B control lines act as interrupt inputs or as handshake outputs. As with CA1 and CA2, each line controls an interrupt flag with a corresponding interrupt enable bit. In addition, these lines act as a serial port under control of the Shift Register. These lines represent one standard TTL load in the input mode and will drive one standard TTL load in the output mode. In addition, they are capable of sourcing 3.0 ma at 1.5 VDC in the output mode to allow the outputs to directly drive Darlington transistor switches.

Figure 5. PERIPHERAL DATA OUTPUT BUFFERS



SY6522 OPERATION

This section contains a discussion of the various blocks of logic shown in Figure 1. In addition, the internal operation of the SY6522 is described in detail.

A. Data Bus Buffers (DB), Peripheral A Buffers (PA), Peripheral B Buffers (PB)

The characteristics of the buffers which provide the required voltage and current drive capability were discussed in the previous section. Electrical parameters for these buffers are specified elsewhere in this document.

B. Chip Access Control

The Chip Access Control contains the necessary logic to detect the chip select condition and to decode the Register Select inputs to allow addressing the desired internal registers. In addition, the R/W and Φ2 signals are utilized to control the direction and timing of data transfers. When writing into the SY6522, data is first latched into a data input register during Φ2. Data is then transferred into the desired internal register during Φ2 · Chip Select. This allows the peripheral I/O lines to change states cleanly. When the processor reads the SY6522, data is transferred from the desired internal register directly onto the Data Bus during Φ2.

C. Port A Registers, Port B Registers

These registers are used in accessing each of the 8-bit peripheral ports. Each port has a Data Direction Register (DDRA, DDRB) for specifying whether the peripheral pins are to act as inputs or outputs. A 0 in a bit of the Data Direction Register causes the corresponding peripheral pin to act as an input. A 1 causes the pin to act as an output.

Each peripheral pin is also controlled by a bit in the Output Register (ORA, ORB) and an Input Register (IRA, IRB). When the pin is programmed to act as an output, the voltage on the pin is controlled by the corresponding bit of the Output Register. A 1 in the Output Register causes the pin to go high, and a 0 causes the pin to go low. Data can be written into Output Register bits corresponding to pins which are programmed to act as inputs; however, the pin will be unaffected.

Reading a peripheral port causes the contents of the Input Register (IRA, IRB) to be transferrred onto the Data Bus. With input latching disabled, IRA will always reflect the data on the PA pins. With input latching enabled, IRA will reflect the contents of the Port A prior to setting the CA1 Interrupt Flag (IFR1) by an active transition on CA1.

The IRB register operates in a similar manner. However, for output pins, the corresponding IRB bit will reflect the contents of the Output Register bit instead of the actual pin. This allows proper data to be read into the processor if the output pin is not allowed to go to full voltage. With input latching enabled on Port B, setting CB1 interrupt flag will cause the IRB to latch this combination of input data and ORB data until the interrupt flag is cleared.

D. Handshake Control

The SY6522 allows very positive control of data transfers between the system processor and peripheral devices through the operation of "handshake" lines. Port A lines (CA1, CA2) handshake data on both a read and a write operation while the Port B lines (CB1, CB2) handshake on a write operation only.

Read Handshake

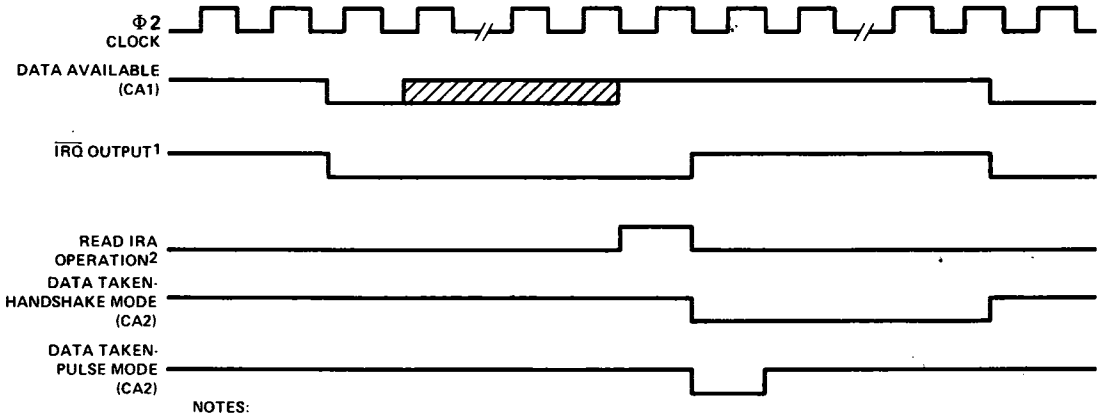
Positive control of data transfers from peripheral devices into the system processor can be accomplished very effectively using "Read" handshaking. In this case, the peripheral device must generate "Data Ready" to signal the processor that valid data is present on the peripheral port. This signal normally interrupts the processor, which then reads the data and issues a "Data Taken" signal. The peripheral device responds by making new data available and repeats until the data transfer is complete.

In the SY6522, automatic "Read" handshaking is possible on the Peripheral A port only. The CA1 interrupt input pin accepts the "Data Ready" signal and generates the "Data Taken" signal. The Data Ready signal will set an internal flag which can cause an interrupt to the processor or which can be polled under software control. The Data Taken signal can either be set high by an active transition on CA1 which is set low by the system processor and cleared by the Data Ready signal. Figure 6 which illustrates the normal Read Handshake sequence.

Write Handshake

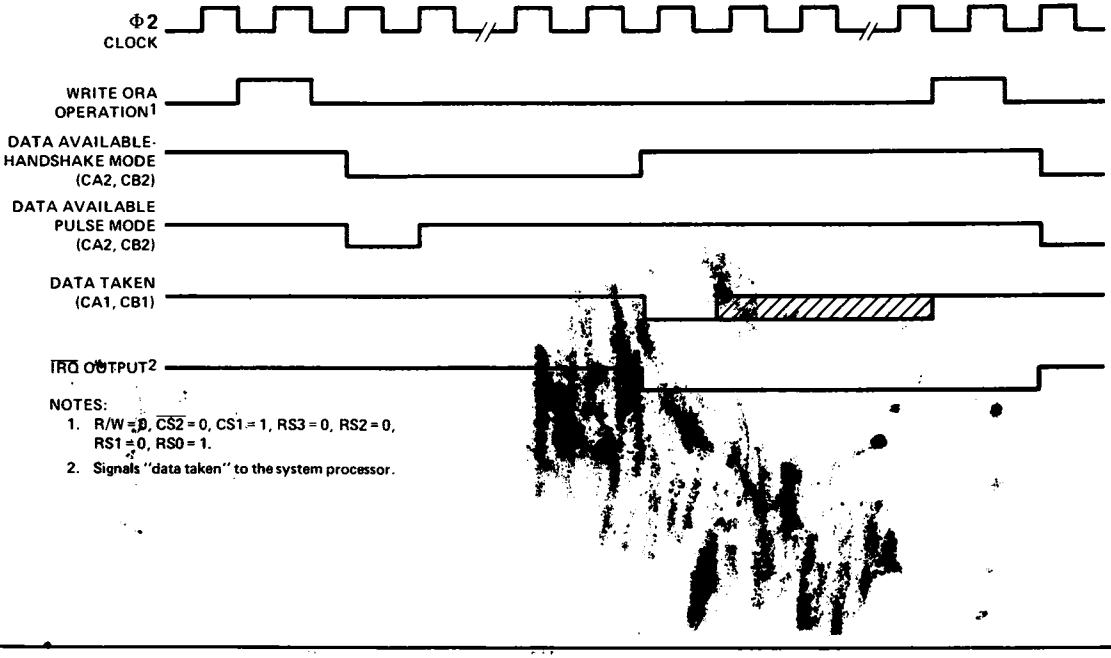
The sequence of operations which allows handshaking data from the system processor to a peripheral device is very similar to that described in Section A for Read Handshaking. However, for "Write" handshaking, the processor must generate the "Data Ready" signal (through the SY6522) and the peripheral device must respond with the "Data Ready" signal. This can be accomplished on both the PA port and the PB port on the SY6522. CA2 or CB2 acts as a Data Ready Output in either the DC level of pulse mode and CA1 or CB1 accepts the "Data Taken" signal from the peripheral device, setting the interrupt flag and clearing the "Data Ready" output. This sequence is shown in Figure 7.

Figure 6. READ HANDSHAKE TIMING SEQUENCE



NOTES:
1. Signals "data available" to the system processor.
2. R/W = 1, $\overline{CS2}$ = 0, CS1 = 1, RS2 = 0, RS3 = 0, RS0 = 1.

Figure 7. WRITE HANDSHAKE TIMING SEQUENCE



NOTES:
1. R/W = 0, $\overline{CS2}$ = 0, CS1 = 1, RS3 = 0, RS2 = 0, RS1 = 0, RS0 = 1.
2. Signals "data taken" to the system processor.

E. Timer 1

Interval Timer T1 consists of two 8-bit latches and a 16-bit counter. The latches are used to store data which is to be loaded into the counter. After loading, the counter decrements at system clock rate, i.e., under control of the clock applied to the Phase Two input pin. Upon reaching zero, an interrupt flag will be set, and $\overline{IRQ}$ will go low. The timer will then disable any further interrupts, or will automatically transfer the contents of the latches into the counter and will continue to decrement. In addition, the timer can be instructed to invert the output signal on a peripheral pin each time it "times-out". Each of these modes is dicussed separately below.

Writing the Timer 1 Registers

The operations which take place when writing to each of the four T1 addresses are as follows:

RS3	RS2	RS1	RS0	Operation (R/W =L)
L	H	L	L	Write into low order latch.
				Write into high order latch.
L	H	L	H	Write into high order counter. Transfer low order latch into low order counter. Reset T1 interrupt flag.
L	H	H	L	Write into low order latch.
L	H	H	H	Write into high order latch. Reset T1 interrupt flag.

Note that the processor does not write directly into the low order counter (T1C-L). Instead, this half of the counter is loaded automatically from the low order latch when the processor writes into the high order counter. In fact, it may not be necessary to write to the low order counter in some applications since the timing operation is triggered by writing to the high order counter.

The second set of addresses allows the processor to write into the latch register without affecting the count-down in progress. This is discussed in detail below.

Reading the Timer 1 Registers

For reading the Timer 1 registers, the four addresses relate directly to the four registers as follows.

RS3	RS2	RS1	RS0	Operation (R/W = H)
L	H	L	L	Read T1 low order counter. Reset T1 interrupt flag.
L	H	L	H	Read T1 high order counter.
L	H	H	L	Read T1 low order latch.
L	H	H	H	Read T1 high order latch.

Timer 1 Operating Modes

Two bits are provided in the Auxiliary Control Register to allow selection of the T1 operating modes. These bits and the four possible modes are as follows;

ACR7 Output Enable	ACR6 "Free-Run" Enable	Mode
0	0	Generate a single time-out interrupt each time T1 is loaded. PB7 disabled.
0	1	Generate continuous interrupts. PB7 disabled.
1	0	Generate a single interrupt and an output pulse on PB7 for each T1 load operation.
1	1	Generate continuous interrupts and a square wave output on PB7.

TIMER 1 ONE-SHOT MODE

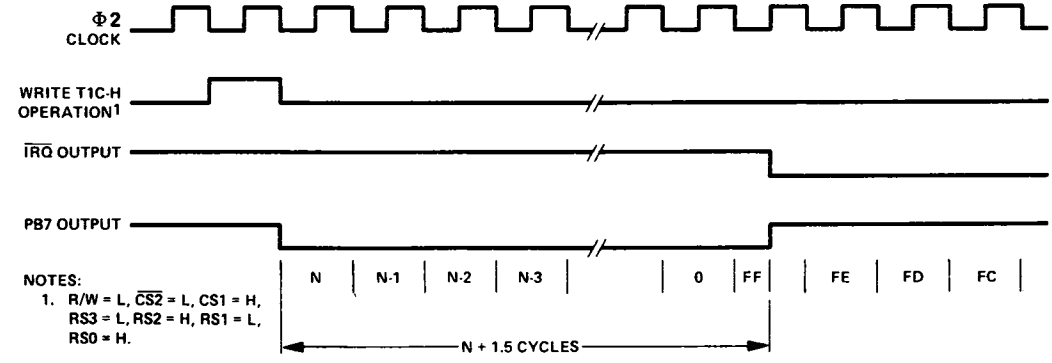
The interval timer one-shot mode allows generation of a single interrupt for each timer load operation. As with any interval timer, the delay between the "write T1C-H" operation and generation of the processor interrupt is a direct function of the data loaded into the timing counter. In addition to generating a single interrupt, Timer 1 can be programmed to produce a single negative pulse on the PB7 peripheral pin. With the output enabled (ACR7=1) a "write T1C-H" operation will cause PB7 to go low. PB7 will return high when Timer 1 times out. The result is a single programmable width pulse.

> **NOTE**
>
> PB7 will act as an output if DDRB7 = 1 or if ACR7 = 1. However, if both DDRB7 and ACR7 are logic 1, PB7 will be controlled from Timer 1 and ORB7 will have no effect on the pin.

In the one-shot mode, writing into the high order latch has no effect on the operation of Timer 1. However, it will be necessary to assure that the low order latch contains the proper data before initiating the count-down with a "write T1C-H" operation.When the processor writes into the high order counter, the T1 interrupt flag will be cleared, the contents of the low order latch will be transferred into the low order counter, and the timer will begin to decrement at system clock rate. If the PB7 output is enabled, this signal will go low on the phase two following the write operation. When the counter reaches zero, the T1 interrupt flag will be set, the $\overline{IRQ}$ pin will go low (interrupt enabled), and the signal on PB7 will go high. At this time the counter will continue to decrement at system clock rate. This allows the system processor to read the contents of the counter to determine the time since interrupt. However, the T1 interrupt flag cannot be set again unless it has been cleared as described elsewhere in this specification.

Timing for the SY6522 interval timer one-shot modes is shown in figure 8.

Figure 8. INTERVAL TIMER "ONE-SHOT" MODE TIMING SEQUENCE



NOTES:
1. R/W = L, $\overline{CS2}$ = L, CS1 = H, RS3 = L, RS2 = H, RS1 = L, RS0 = H.

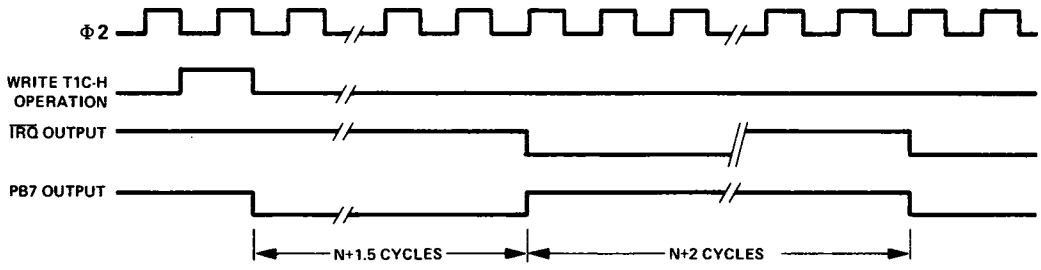
TIMER 1 FREE-RUNNING MODE

The most important advantage associated with the latches in T1 is the ability to produce a continuous series of evenly spaced interrupts and the ability to produce a square wave on PB7 whose frequency is not affected by variations in the processor interrupt response time. This is accomplished in the "free-running" mode.

In the free-running mode (ACR6 = 1), the interrupt flag is set and the signal on PB7 is inverted each time the counter reaches zero. However, instead of continuing to decrement from zero after a time-out, the timer automatically transfers the contents of the latch into the counter (16 bits) and continues to decrement from there. The interrupt flag can be cleared by writing T1C-H, by reading T1C-L, or by writing directly into the flag as described below. However, it is not necessary to rewrite the timer to enable setting the interrupt flag on the next time-out.

All interval timers in the SY6500 family devices are "re-triggerable". Rewriting the counter will always re-initialize the time-out period. In fact, the time-out can be prevented completely if the processor continues to rewrite the timer before it reaches zero. Timer 1 will operate in this manner if the processor writes into the high order counter (T1C-H). However, by loading the latches only, the processor can access the timer during each down-counting operation without affecting the time-out in process. Instead, the data loaded into the latches will determine the length of the next time-out period. This capability is particularly valuable in the free-running mode with the output enabled. In this mode, the signal on PB7 is inverted and the interrupt flag is set with each time-out. By responding to the interrupts with new data for the latches, the processor can determine the period of the next half cycle during each half cycle of the output signal on PB7. In this manner, very complex waveforms can be generated. Timing for the free-running mode is shown in Figure 9.

Figure 9. TIMER 1 "FREE-RUNNING" MODE



F. Timer 2

Timer 2 operates as an interval timer (in the "one-shot" mode only), or as a counter for counting negative pulses on the PB6 peripheral pin. A single control bit is provided in the Auxiliary Control Register to select between these two modes. This timer is comprised of a "write-only" low-order latch (T2L-L), a "read-only" low-order counter and a read/write high order counter. The counter registers act as a 16-bit counter which decrements at Φ2 rate.

Timer 2 addressing can be summarized as follows:

RS3	RS2	RS1	RS0	R/W = 0	R/W = 1
H	L	L	L	Write T2L-L	Read T2C-L Clear Interrupt flag
H	L	L	H	Write T2C-H Transfer T2L-L to T2C-L Clear Interrupt flag	Read T2C-H

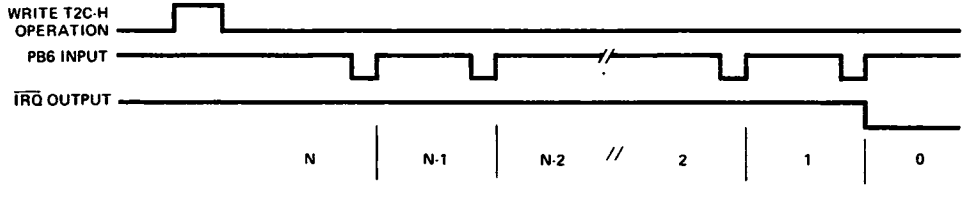
Timer 2 Interval Timer Mode

As an interval timer, T2 operates in the "one-shot" mode similar to Timer 1. In this mode, T2 provides a single interrupt for each "write T2C-H" operation. After timing out, the counter will continue to decrement. However, setting of the interrupt flag will be disabled after initial time-out so that it will not be set by the counter continuing to decrement through zero. The processor must rewrite T2C-H to enable setting of the interrupt flag. The interrupt flag is cleared by reading T2C-L or by writing T2C-H. Timing for this operation is shown in Figure 8.

Timer 2 Pulse Counting Mode

In the pulse counting mode, T2 serves primarily to count a predetermined number of negative-going pulses on PB6. This is accomplished by first loading a number into T2. Writing into T2C-H clears the interrupt flag and allows the counter to decrement each time a pulse is applied to PB6. The interrupt flag will be set when T2 reaches zero. At this time the counter will continue to decrement with each pulse on PB6. However, it is necessary to rewrite T2C-H to allow the interrupt flag to set on subsequent down-counting operations. Timing for this mode is shown in Figure 10. The pulse must be low on the leading edge of Φ2.

Figure 10. TIMER 2 PULSE COUNTING MODE



G. Shift Register

The Shift Register (SR) performs serial data transfers into and out of the CB2 pin under control of an internal modulo-8 counter. Shift pulses can be applied to the CB1 pin from an external source or, with the proper mode selection, shift pulses generated internally will appear on the CB1 pin for controlling external devices.

The control bits which select the various shift register operating modes are located in the Auxiliary Control Register. These bits can be set and cleared by the system processor to select one of the operating modes discussed in the following paragraphs.

Shift Register Input Modes

Bit 4 of the Auxiliary Control Register selects the input or output modes. There are three input modes and four output modes, differing primarily in the source of the pulses which control the shifting operation. With ACR4 = 0 the input modes are selected by ACR3 and ACR2 as follows:

ACR4	ACR3	ACR2	Mode
0	0	0	Shift Register Disabled
0	0	1	Shift in under control of Timer 2
0	1	0	Shift in at System Clock Rate.
0	1	1	Shift in under control of external input pulses

Mode 000 - Shift Register Disabled

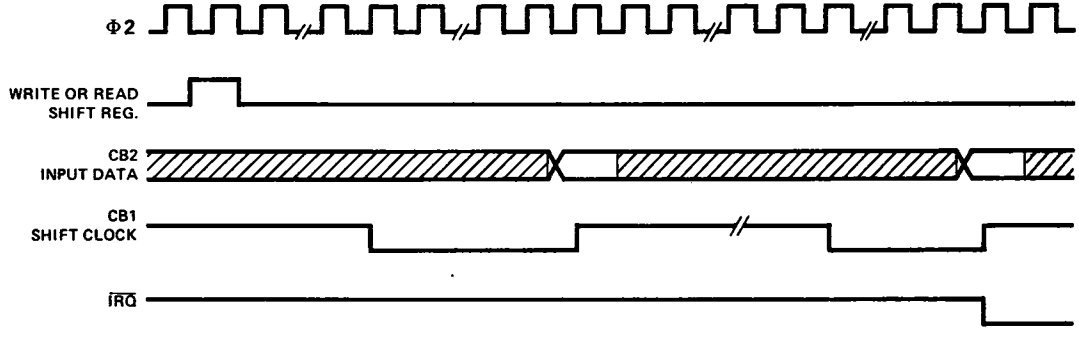
The 000 mode is used to disable the Shift Register. In this mode the microprocessor can write or read the SR, but the shifting operation is disabled and operation of CB1 and CB2 is controlled by the appropriate bits in the Peripheral Control Register (PCR). In this mode the SR Interrupt Flag is disabled (held to a logic 0).

Mode 001 - Shift in Under Control of Timer 2

In this mode the shifting rate is controlled by the low order 8 bits of T2. Shift pulses are generated on the CB1 pin to control shifting in external devices. The time between transitions of this output clock is a function of the system clock period and the contents of the low order T2 latch.

The shifting operation is triggered by writing or reading the shift register. Data is shifted first into the low order bit of SR and is then shifted into the next higher order bit or the shift register on the trailing edge of each clock pulse. As shown in Figure 11, the input data should change before the leading edge of the clock pulse. This data is loaded into the shift register during the system clock cycle following the trailing edge of the clock pulse. After 8 clock pulses, the shift register interrupt flag will be set and IRQ will go low.

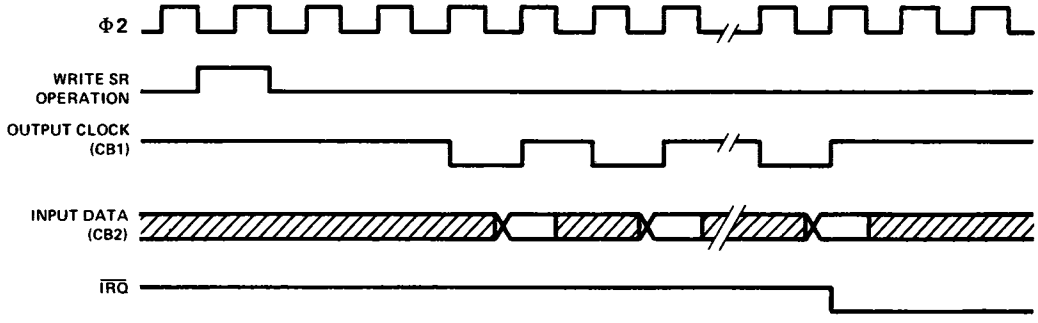
Figure 11. SHIFTING IN UNDER CONTROL OF T2



Mode 010 - Shift in at System Clock Rate

In this mode the shift rate is a direct function of the system clock frequency. CB1 becomes an output which generates shift pulses for controlling external devices. Timer 2 operates as an independent interval timer and has no effect on SR. The shifting operation is triggered by reading or writing the Shift Register. Data is shifted first into bit 0 and is then shifted into the next higher order bit of the shift register on the trailing edge of each clock pulse. After 8 clock pulses, the shift register interrupt flag will be set, and the output clock pulses on CB1 will stop.

Figure 12. TIMING SEQUENCE FOR SHIFTING IN AT SYSTEM CLOCK RATE

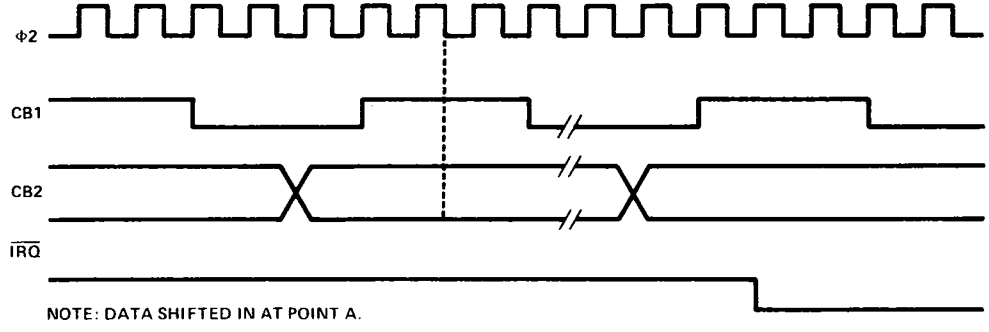


Mode 011 - Shift in Under Control of External Clock

In this mode CB1 becomes an input. This allows an external device to load the shift register at its own pace. The shift register counter will interrupt the processor each time 8 bits have been shifted in. However, the shift register counter does not stop the shifting operation; it acts simply as a pulse counter. Reading or writing the Shift Register resets the Interrupt flag and initializes the SR counter to count another 8 pulses.

Note that the data is shifted during the first system clock cycle following the leading edge of the CB1 shift pulse. For this reason, data must be held stable during the first full cycle following CB1 going high. Timing for this operation is shown in Figure 13.

Figure 13. TIMING SEQUENCE FOR SHIFTING IN UNDER CONTROL OF EXTERNAL CLOCK



Shift Register Output Modes

The four Shift Register Output Modes are selected by setting the Input/Output Control Bit (ACR4) to a logic 1 and then selecting the specific output mode with ACR3 and ACR2. In each of these modes the Shift Register shifts data out of bit 7 to the CB2 pin. At the same time the contents of bit 7 are shifted back into bit 0. As in the input modes, CB1 is used either as an output to provide shifting pulses out or as an input to allow shifting from an external pulse. The four modes are as follows:

ACR4	ACR3	ACR2	Mode
1	0	0	Shift out - Free-running mode. Shift rate controlled by T2.
1	0	1	Shift out - Shift rate controlled by T2. Shift pulses generated on CB1.
1	1	0	Shift out at system clock rate.
1	1	1	Shift out under control of an external pulse.

Mode 100 Free-Running Output

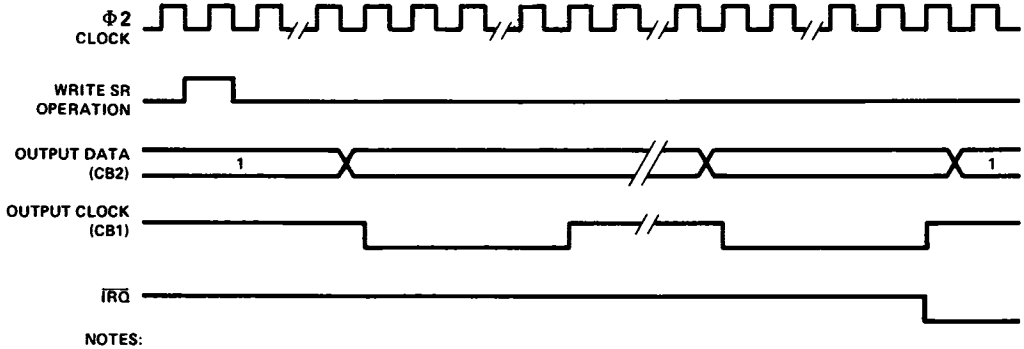
This mode is very similar to mode 101 in which the shifting rate is set by T2. However, in mode 100 the SR Counter does not stop the shifting operation. Since the Shift Register bit 7 (SR7) is recirculated back into bit 0, the 8 bits loaded into the shift register will be clocked onto CB2 repetitively. In this mode the shift register counter is disabled.

Mode 101 - Shift out Under Control of T2

In this mode the shift rate is controlled by T2 (as in the previous mode). However, with each read or write of the shift register the SR Counter is reset and 8 bits are shifted onto CB2. At the same time, 8 shift pulses are generated on CB1 to control shifting in External devices. After the 8 shift pulses, the shifting is disabled, the SR Interrupt Flag is set and CB2 goes to a state determined by the CB2 Control bit (PC5) in the Peripheral Control Register.

The CB2 Control bits (PC7, PC6, and PC5) must be used to set CB2 to a manual output selecting either a high or low polarity. If the shift register is reloaded before the last time-out, the shifting will continue. This sequence is illustrated in Figure 14.

Figure 14. SHIFTING OUT UNDER CONTROL OF T2

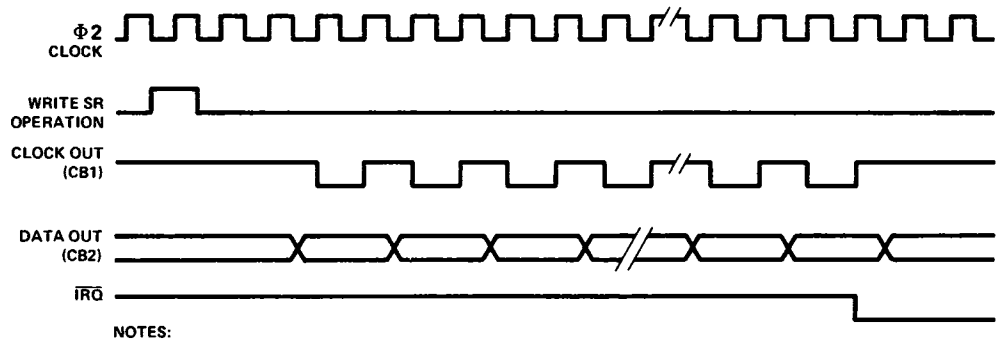


NOTES:
1. DATA OUT DETERMINED BY CB2 CONTROL IN PCR.

Mode 110 - Shifting out at System Clock Rate

In this mode the shift register operation is similar to that shown in Figure 11. However, the shifting rate is a function of the system clock on the chip enable pin (Φ2) and is independent of T2. Timer 2 resumes its normal function as an independent interval timer. Figure 15 illustrates the timing sequence for mode 110.

Figure 15. SHIFTING OUT UNDER CONTROL OF SYSTEM CLOCK

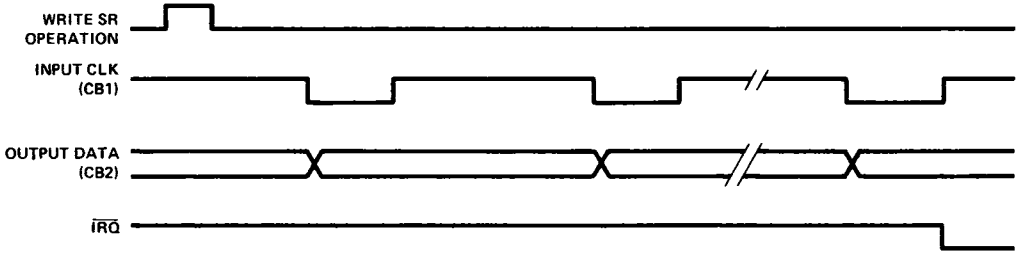


NOTES:
1. Data out determined by CB2 control in PCR.

Mode 111 - Shift out under Control of an External Pulse

In this mode, shifting is controlled by pulses applied to the CB1 pin by an external device. The SR counter sets the SR Interrupt flag each time it counts 8 pulses but it does not disable the shifting function. Each time the microprocessor writes or reads the shift register, the SR Interrupt flag is reset and the SR counter is initialized to begin counting the next 8 shift pulses on pin CB1. After 8 shift pulses, the interrupt flag is set. The microprocessor can then load the shift register with the next byte of data.

Figure 16. SHIFTING OUT UNDER CONTROL OF EXTERNAL CLOCK



H. Interrupt Control

Controlling interrupts within the SY6522 involves three principal operations. These are flagging the interrupts, enabling interrupts and signalling to the processor that an active interrupt exists within the chip. Interrupt flags are set by interrupting conditions which exist within the chip or on inputs to the chip. These flags normally remain set until the interrupt has been serviced. To determine the source of an interrupt, the microprocessor must examine these flags in order from highest to lowest priority. This is accomplished by reading the flag register into the processor accumulator, shifting this register either right or left and then using conditional branch instructions to detect an active interrupt.

Associated with each interrupt flag is an interrupt enable bit. This bit can be set or cleared by the processor to enable interrupting the processor from the corresponding interrupt flag. If an interrupt flag is set to a logic 1 by an interrupting condition, and the corresponding interrupt enable bit is set to a 1, the Interrupt Request Output ($\overline{IRQ}$) will go low. $\overline{IRQ}$ is an "open-collector" output which can be "wire-or'ed" with other devices in the system to interrupt the processor.

In the SY6522, all the interrupt flags are contained in one register. In addition, bit 7 of this register will be read as a logic 1 when an interrupt exists within the chip. This allows very convenient polling of several devices within a system to locate the source of an interrupt.

REGISTER NAME	REGISTER BIT							
	7	6	5	4	3	2	1	0
Interrupt Flag Register (IFR)	IRQ	T1	T2	CB1	CB2	SR	CA1	CA2
Interrupt Enable Register (IFR)	Set/ clear control	T1	T2	CB1	CB2	SR	CA1	CA2

Interrupt Flag Register

The IFR is a read/bit-clear register. When the proper chip select and register signals are applied to the chip, the contents of this register are placed on the data bus. Bit 7 indicates the status of the $\overline{IRQ}$ output. This bit corresponds to the logic function: IRQ = IFR6 x IER6 + IFR5 x IER5 + IFR4 x IER4 + IFR3 x IER3 + IFR2 x IER2 + IFR1 x IER1 + IFR0 x IER0. Note: X = logic AND, + = Logic OR.

Bits six through zero are latches which are set and cleared as follows:

Bit #	Set by	Cleared By
0	Active transition of the signal on the CA2 pin.	Reading or writing the A port Output Register (ORA) using address 0001.
1	Active transition of the signal on the CA1 pin.	Reading or writing the A Port Output Register (ORA) using address 0001.
2	Completion of eight shifts.	Reading or writing the Shift Register.
3	Active transition of the signal on the CB2 pin.	Reading or writing the B Port Output Register.
4	Active transition of the signal on the CB1 pin.	Reading or writing the B Port Output Register.
5	Time-out of Timer 2.	Reading T2 low order counter. Writing T2 high order counter.
6	Time-out of Timer 1.	Reading T1 low order counter. Writing T1 high order counter.

The IFR bit 7 is not a flag. Therefore, this bit is not directly cleared by writing a logic 1 into it. It can only be cleared by clearing all the flags in the register or by disabling all the active interrupts as discussed in the next section.

Interrupt Enable Register (IER)

For each interrupt flag in IFR, there is a corresponding bit in the Interrupt Enable Register. The system processor can set or clear selected bits in this register to facilitate controlling individual interrupts without affecting others. This is accomplished by writing to address 1110 (IER address). If bit 7 of the data placed on the system data bus during this write operation is a 0, each 1 in bits 6 through 0 clears the corresponding bit in the Interrupt Enable Register. For each zero in bits 6 through 0, the corresponding bit is unaffected.

Setting selected bits in the Interrupt Enable Register is accomplished by writing to the same address with bit 7 in the data word set to a logic 1. In this case, each 1 in bits 6 through 0 will set the corresponding bit. For each zero, the corresponding bit will be unaffected. This individual control of the setting and clearing operations allows very convenient control of the interrupts during system operation.

In addition to setting and clearing IER bits, the processor can read the contents of this register by placing the proper address on the register select and chip select inputs with the R/W line high. Bit 7 will be read as a logic 0.

I. Function Control

Control of the various functions and operating modes within the SY6522 is accomplished primarily through two registers, the Peripheral Control Register (PCR) and the Auxiliary Control Register (ACR). The PCR is used primarily to select the operating mode for the four peripheral control pins. The Auxiliary Control Register selects the operating mode for the interval timers (T1, T2), and the serial port (SR).

Peripheral Control Register

The Peripheral Control Register is organized as follows:

Bit #	7 6 5	4	3 2 1	0
Function	CB2 Control	CB1 Control	CA2 Control	CA1 Control

Each of these functions is discussed in detail below.

1. CA1 Control

Bit 0 of the Peripheral Control Register selects the active transition of the input signal applied to the CA1 interrupt input pin. If this bit is a logic 0, the CA1 interrupt flag will be set by a negative transition (high to low) of the signal on the CA1 pin. If PCR0 is a logic 1, the CA1 interrupt flag will be set by a positive transition (low to high) of this signal.

2. CA2 Control

The CA2 pin can be programmed to act as an interrupt input or as a peripheral control output. As an input, CA2 operates in two modes, differing primarily in the methods available for resetting the interrupt flag. Each of these two input modes can operate with either a positive or a negative active transition as described above for CA1.

In the output mode, the CA2 pin combines the operations performed on the CA2 and CB2 pins of the SY6522. This added flexibility allows processor to perform a normal "write" handshaking in a system which uses CB1 and CB2 for the serial operations described above. The CA2 operating modes are selected as follows:

PCR3	PCR2	PCR1	Mode
0	0	0	Input mode–Set CA2 interrupt flag (IFR0) on a negative transition of the input signal. Clear IFR0 on a read or write of the Peripheral A Output Register.
0	0	1	Independent interrupt input mode–Set IFR0 on a negative transition of the CA2 input signal. Reading or writing ORA does not clear the CA2 Interrupt flag.
0	1	0	Input mode–Set CA2 interrupt flag on a positive transition of the CA2 input signal. Clear IFR0 with a read or write of the Peripheral A Output Register.
0	1	1	Independent Interrupt input mode–Set IFR0 on a positive transition of the CA2 input signal. Reading or writing ORA does not clear the CA2 interrupt flag.
1	0	0	Handshake output mode–Set CA2 output low on a read or write of the Peripheral A Output Register. Reset CA2 high with an active transition on CA1.
1	0	1	Pulse Output mode–CA2 goes low for one cycle following a read or write of the Peripheral A Output Register.
1	1	0	Manual output mode–The CA2 output is held low in this mode.
1	1	1	Manual output mode–The CA2 output is held high in this mode.

In the independent input mode, writing or reading the ORA register has no effect on the CA2 interrupt flag. This flag must be cleared by writing a logic 1 into the appropriate IFR bit. This mode allows the processor to handle interrupts which are independent of any operations taking place on the peripheral I/O ports.

The handshake and pulse output modes have been described previously. Note that the timing of the output signal varies slightly depending on whether the operation is initiated by a read or a write.

3. CB1 Control

Control of the active transition of the CB1 input signal operates in exactly the same manner as that described above for CA1. If PCR4 is a logic 0 the CB1 interrupt flag (IFR4) will be set by a negative transition of the CB1 input signal and cleared by a read or write of the ORB register. If PCR4 is a logic 1, IFR4 will be set by a positive transition of CB1.

If the Shift Register function has been enabled, CB1 will act as an input or output for the shift register clock signals. In this mode the CB1 interrupt flag will still respond to the selected transition of the signal on the CB1 pin.

4. CB2 Control

With the serial port disabled, operation of the CB2 pin is a function of the three high order bits of the PCR. The CB2 modes are very similar to those decribed previously for CA2. These modes are selected as follows:

PCR7	PCR6	PCR5	Mode
0	0	0	Interrupt input mode–Set CB2 interrupt flag (IFR3) on a negative transition of the CB2 input signal. Clear IFR3 on a read or write of the Peripheral B Output Register.
0	0	1	Independent interrupt input mode–Set IFR3 on a negative transition of the CB2 input signal. Reading or writing ORB does not clear the interrupt flag.
0	1	0	Input mode–Set CB2 interrupt flag on a positive transition of the CB2 input signal. Clear the CB2 interrupt flag on a read or write of ORB.
0	1	1	Independent input mode–Set IFR3 on a positive transition of the CB2 input signal. Reading or writing ORB does not clear the CB2 interrupt flag.
1	0	0	Handshake output mode–Set CB2 low on a write ORB operation. Reset CB2 high with an active transition of the CB1 input signal.
1	0	1	Pulse output mode–Set CB2 low for one cycle following a write ORB operation.
1	1	0	Manual output mode–The CB2 output is held low in this mode.
1	1	1	Manual output mode–The CB2 output is held high in this mode.

AUXIALIARY CONTROL REGISTER

Many of the functions in the Auxiliary Control Register have been discussed previously. However, a summary of this register is presented here as a convenient reference for the SY6522 user. The Auxiliary Control Register is organized as follows:

Bit #	7 6	5	4 3 2	1	0
Function	T1 Control	T2 Control	Shift Register Control	PB Latch Enable	PA Latch Enable

1. PA Latch Enable

The SY6522 provides input latching on both the PA and PB ports. In this mode, the data present on the peripheral A input pins will be latched within the chip when the CA1 interrupt flag is set. Reading the PA port will result in these latches being transferred into the processor. As long as the CA1 interrupt flag is set, the data on the peripheral pins can change without affecting the data in the latches. This input latching can be used with any of the CA2 input or output modes.

It is important to note that on the PA port, the processor always reads the data on the peripheral pins (as reflected in the latches). For output pins, the processor still reads the latches. This may or may not reflect the data currently in the ORA. Proper system operation requires careful planning on the part of the system designer if input latching is combined with output pins on the peripheral ports.

Input latching is enabled by setting bit 0 in the Auxiliary Control Register to a logic 1. As long as this bit is a 0, the latches will directly reflect the data on the pins.

2. PB Latch Enable

Input latching on the PB port is controlled in the same manner as that described for the PA port. However, with the peripheral B port the input latch will store either the voltage on the pin or the contents of the Output Register (ORB) depending on whether the pin is programmed to act as an input or an output. As with the PA port, the processor always reads the input latches.

3 Shift Register Control

The Shift Register operating mode is selected as follows:

ACR4	ACR3	ACR2	Mode
0	0	0	Shift Register Disabled.
0	0	1	Shift in under control of Timer 2.
0	1	0	Shift in under control of system clock.
0	1	1	Shift in under control of external clock pulses.
1	0	0	Free-running output at rate determined by Timer 2.
1	0	1	Shift out under control of Timer 2.
1	1	0	Shift out under control of the system clock.
1	1	1	Shift out under control of external clock pulses.

4. T2 Control

Timer 2 operates in two modes. If ACR5 = 0, T2 acts as an interval timer in the one-shot mode. If ACR5 = 1, Timer 2 acts to count a predetermined number of pulses on pin PB6.

5. T1 Control

Timer 1 operates in the one-shot or free-running mode with the PB7 output control enabled or disabled. These modes are selected as follows:

ACR7	ACR6	Mode
0	0	One-shot mode–Output to PB7 disabled
0	1	Free-running mode–Output to PB7 disabled.
1	0	One-shot mode–Output to PB7 enabled.
1	1	Free-running mode–Output to PB7 enabled.

APPLICATION OF THE SY6522

The SY6522 represents a significant advance in general-purpose microprocessor I/O. Unfortunately, its many powerful features, coupled with a set of very flexible operating modes, cause this device to appear to be very complex at first glance. However, a detailed analysis will show that the VIA is organized to allow convenient control of these powerful features. This section seeks to assist the system designer in his understanding of the SY6522 by illustrating how the device can be used in microprocessor-based systems.

A. Control of the SY6522 Interrupts

Organization of the SY6522 interrupt flags into a single register greatly facilitates the servicing of interrupts from this device. Since there is only one $\overline{IRQ}$ output for the seven possible sources of interrupt within the chip, the processor must examine these flags to determine the cause of an interrupt. This is best accomplished by first transferring the contents of the flag register into the accumulator. At this time it may be necessary to mask off these flags which have been disabled in the Interrupt Enable Register. This is particularly important for the edge detecting inputs where the flags may be set whether or not the interrupting function has been enabled. Masking off these flags can be accomplished by performing an AND operation between the IER and the accumulator or by performing an "AND IMMEDIATE". The second byte of this AND # instruction should specify those flags which correspond to interrupt functions which are to be serviced.

If the N flag is set after these operations, an active interrupt exists within the chips. This interrupt can be detected with a series of shift and branch instructions.

Clearing interrupt flags is accomplished very conveniently by writing a logic 1 directly into the appropriate bit of the Interrupt Flag Register. This can be combined with an interrupt enable or disable operation as follows:

```
LDA #@10010000  ; initialize accumulator
STA IFR         ; clear interrupt flag
STA IER         ; set interrupt enable flag
```

or:

```
LDA #@00001000  ; initialize accumulator
STA IFR         ; clear interrupt flag
STA IER         ; disable interrupt
```

Another very useful technique for clearing interrupt flags is to simply transfer the contents of the flag register back into this register as follows:

```
LDA IFR         ; transfer IFR to accumulator
STA IFR         ; clear flags corresponding to active interrupts
```

After completion of this operation the accumulator will still contain the interrupt flag information. Most important, writing into the flag register clears only those flags which are already set. This eliminates the possibility of inadvertently clearing a flag while it is being set.

B. Use of Timer 1

Timer 1 represents one of the most powerful features of the SY6522. The ability to generate very evenly spaced interrupts and the ability to control the voltage on PB7 makes this timer particularly valuable in various timing, data detection and waveform generation applications.

Time-of-Day Clock Applications

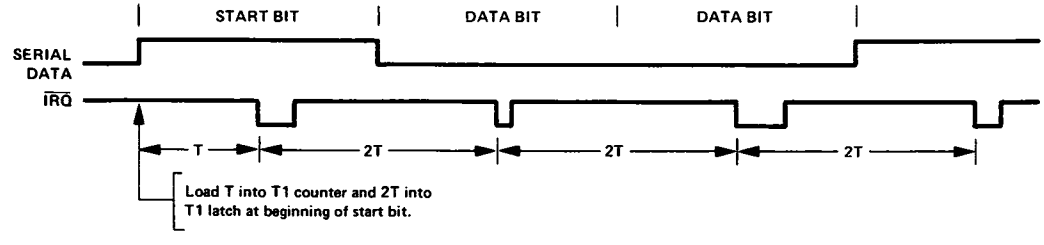
An important feature of many systems is the time-of-day clock. In microprocessor-based systems the time of day is usually maintained in memory and is updated in an interrupt service routine. A regular processor interrupt will then assure that this time of day will always be available when it is needed in the main program.

Generating very regular interrupts using previously available timers presented difficulties because of the need to re-load the timer for each interrupt. Unfortunately, the time between the interrupts will fluctuate due to variations in the interrupt response time. This problem is eliminated in the Timer 1 "free-running" mode. The accuracy of these "free-running" interrupts is only a function of the system clock and is not affected by interrupt response time.

Asynchronous Data Detection

The extraction of clock and data information from serial asynchronous ASCII signals or from any single channel data recording device relies on the ability to establish accurate strobes. As discussed previously, the period of these strobes can be seriously affected by the interrupt response time using conventional timers. However, T1 again allows generation of very accurate interrupts. The processor responds to these interrupts by strobing the input data. The ability to reload the T1 latches without affecting the count-down in progress is very useful in this application. This allows the strobe time to be doubled or halved during data detection. This sequence of operation is as follows:

Figure 17. DETECTING ASYNCHRONOUS DATA USING TIMER 1



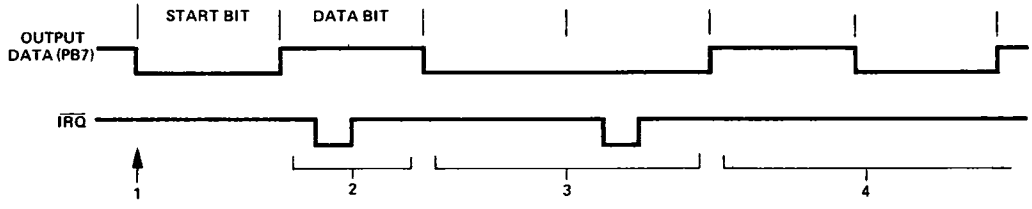
Waveform Generation with Timer 1

In addition to generating processor interrupts, Timer 1 can be used to control the output voltage on peripheral pin PB7 (output mode). In this mode a single negative pulse can be generated on PB7 (one-shot mode) or, in the free-running mode, a continuous waveform can be generated. In this latter mode the voltage on PB7 will be inverted each time T1 times out.

A single solenoid can be triggered very conveniently in the one-shot mode if the PB7 signal is used to control the solenoid directly. With this configuration the solenoid can be triggered by simply writing to T1C-H.

Generating very complex waveforms can be a simple problem if T1 is used to control PB7 in the free-running mode. During any count-down process the latches can be loaded to determine the length of the next count-down period. Figure 18 shows this timing sequence for generating ASCII serial data.

Figure 18. ASCII SERIAL DATA GENERATION USING T1

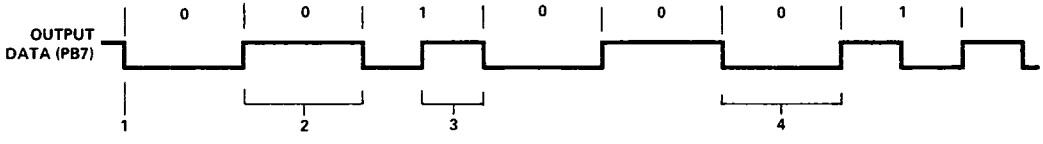


1. Load T into T1 counter and latch. Load T into T2 to trigger T1 latch reload.
2. Load 2T into T1 latch during this bit time. Load 2T into T2, as before.
3. Load T into T1 latch anytime during this period. Load NT into T2. N = number of 1's or 0's which follow.
4. A series of 1's and 0's will be generated until the T1 latch is again changed. Note that the use of T2 to control reloading the T1 latch eliminates the need to interrupt on each transition.

An application where this mode of operation is also very powerful is in the generation of bi-phase encoded data for tape or disk storage. This encoding technique and the sequence of operations which would take place are illustrated in Figure 19.

These applications represent only a tiny portion of the potential T1 applications. Some other possibilities are pulse width modulation waveforms, sound generation for video games, A/D techniques requiring very accurate pulse widths, and waveform synthesis in electronic games.

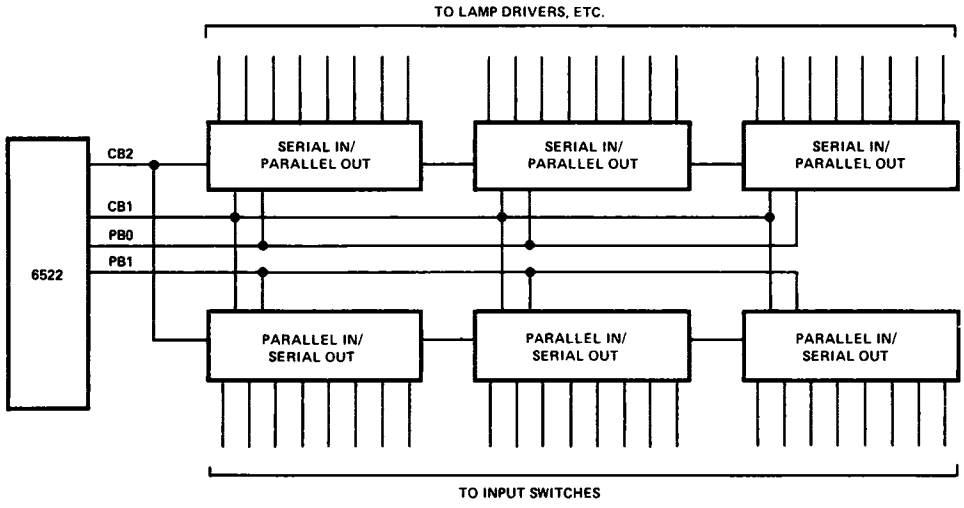
Figure 19. GENERATING BI-PHASE ENCODED DATA



1. Load T1 counter and latch.
2. Shift T1 latch one bit to the right during this period.
3. Shift T1 latch left during this period.
4. Shift T1 latch right during this period.

Note that T1 must be accessed only when the output data changes. A string of 1's or 0's can be generated without processor intervention.

Figure 22. EXPANDING SYSTEM I/O USING SHIFT REGISTER

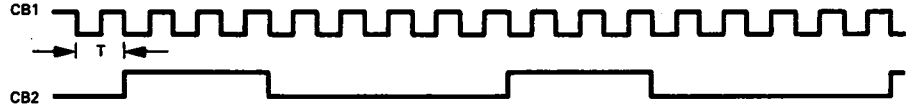


Clock Generation Using the Shift Register

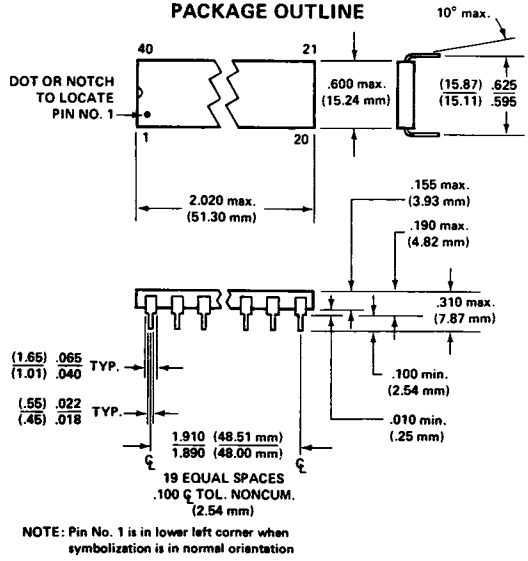
In all output modes the data shifted out of bit 7 will also be shifted into bit 0. For this reason the Shift Register need not be re-loaded if the same data is to be shifted out each time. A Shift Register read operation can be used to trigger the shifting operation.

This capability is very useful for generating peripheral clocks in the continuous output mode. This mode allows an 8-bit pattern to be shifted out continuously. This is illustrated in Figure 23. Note that in this mode the shifting operation is controlled by Timer 2. A single bit time can therefore be up to 256 clock cycles in length.

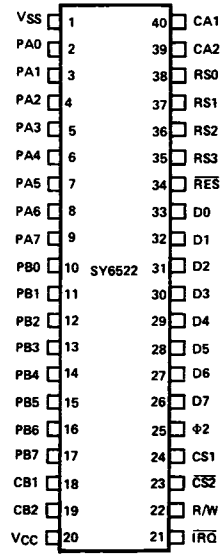
Figure 23. CLOCK GENERATION USING SR FREE-RUNNING MODE



NOTES:
1. Shift Register loaded with 1110 0000_2 initially. 2. T determined by Timer 2.



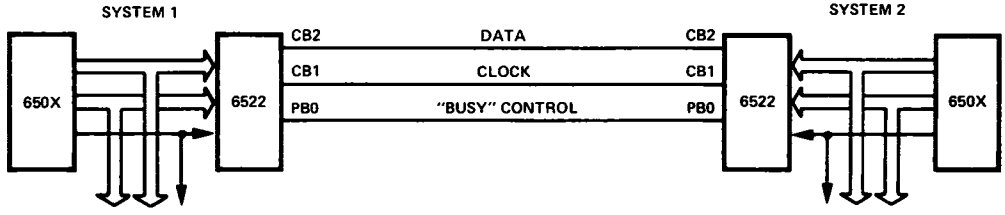
NOTE: Pin No. 1 is in lower left corner when symbolization is in normal orientation



Using the SY6522 Shift Register

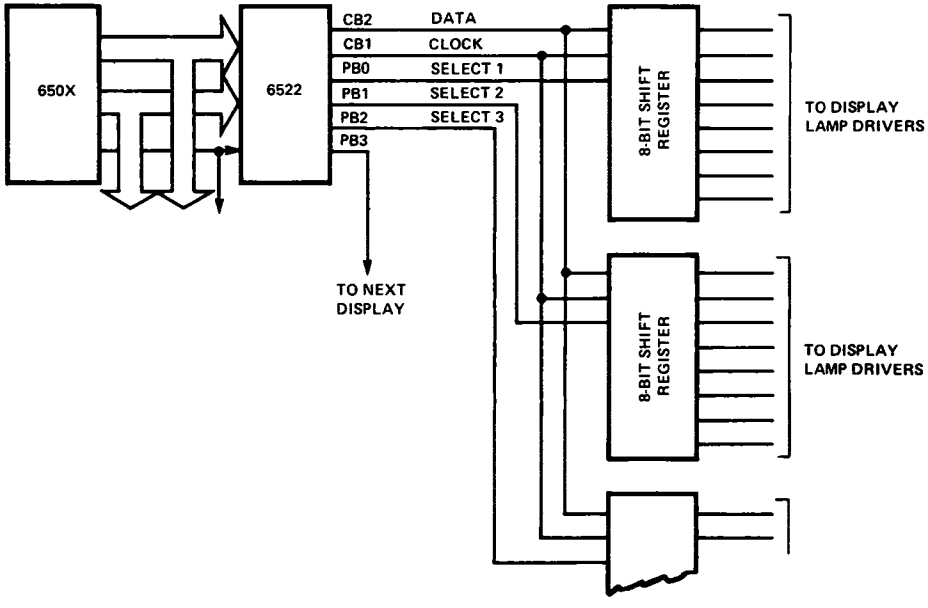
The Shift Register in the SY6522 is designed primarily as a synchronous serial communications port for distributed systems. These systems can be either single-processor with distributed peripheral controllers or distributed processor systems. The most important characteristic of the Shift Register in these applications is its ability to transfer information at relatively slow data rates to allow the use of R-C noise suppression techniques. This transfer can be accomplished while the processor is servicing other aspects of the system. An example of a simple 2-processor distributed system is shown in Figure 20. Use of the SY6522 Shift Register allows effective communication between the two systems without the use of relatively complex asynchronous communications techniques.

Figure 20. USING SHIFT REGISTER FOR INTER-SYSTEM COMMUNICATION



In a system with distributed peripherals, the Shift Register can be used to transfer data to the peripheral interface devices. This is illustrated in Figure 21 for a system with a number of distributed status displays. These displays are serviced by stand-alone controllers which actuate the lamps in the status displays with simple drivers. The data and clock lines are wired in parallel to each unit. In addition, a single SY6522 peripheral port allows selection of the display to be loaded. These select lines can be eliminated if all displays are to contain the same information. With the system shown, the status display can be updated at any time by simply selecting the desired display and then writing to the Shift Register.

Figure 21. USING THE SHIFT REGISTER FOR SERVICING REMOTE STATUS DISPLAYS



Remote input devices can be serviced in much the same manner by shifting data into the Shift Register under control of a peripheral port output as shown in Figure 21. Each set of input switches can be polled by first selecting the set to be polled and then triggering the shifting operation with a Shift Register read operation. A shift register interrupt can be used to cause the processor to read the resulting input information after shifting is complete.

The techniques described above can be utilized to expand I/O capability in a microprocessor based system. In a system with many status lamps or many input switches, simple TTL shift registers will provide the necessary I/O in a very cost effective manner. This is illustrated in Figure 22.

APPENDIX I

SY6532 DATA SHEET

Synertek®

3050 Coronado Drive, Santa Clara, CA. 95051
(408) 984-8900 TWX 910-338-0135

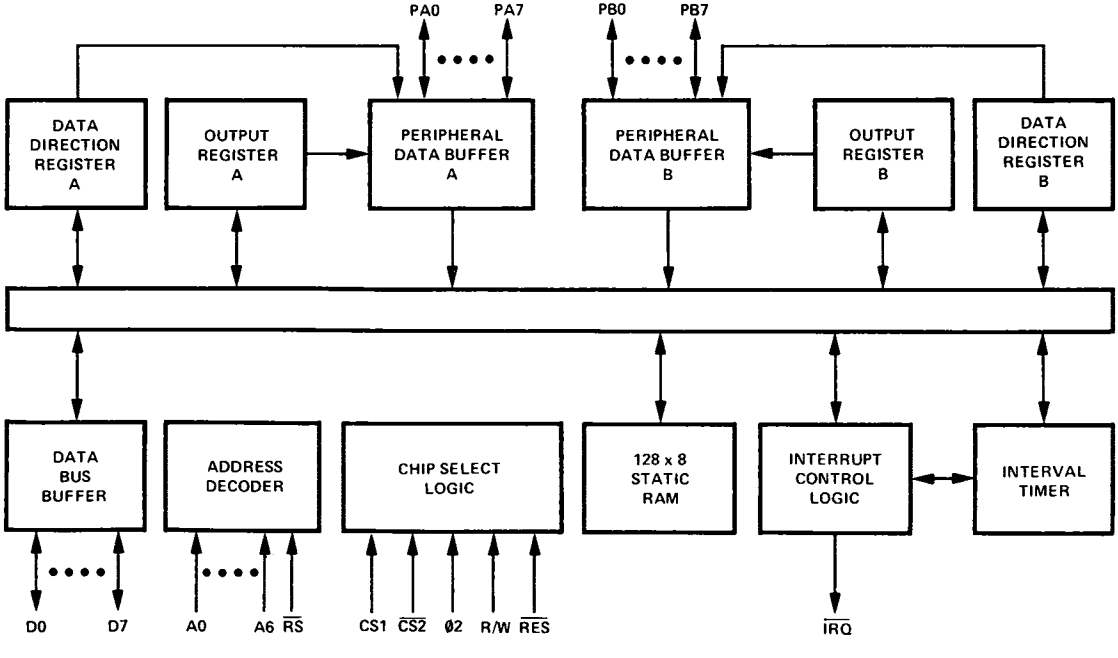
SY6532

SY6532 (RAM, I/O, TIMER ARRAY)

The SY6532 is designed to operate in conjuction with the SY6500 Microprocessor Family. It is comprised of a 128 x 8 static RAM, two software controlled 8 bit bi-directional data ports allowing direct interfacing between the microprocessor unit and peripheral devices, a software programmable interval timer with interrupt capable of timing in various intervals from 1 to 262,144 clock periods, and a programmable edge-detect interrupt circuit.

- 8 bit bi-directional Data Bus for direct communication with the microprocessor
- Programmable edge-sensitive interrupt
- 128 x 8 static RAM
- Two 8 bit bi-directional data ports for interface to peripherals
- Two programmable I/O Peripheral Data Direction Registers
- Programmable Interval Timer
- Programmable Interval Timer Interrupt
- TTL & CMOS compatible peripheral lines
- Peripheral pins with Direct Transistor Drive Capability
- High Impedance Three-State Data Pins

Figure 1. 6532 BLOCK DIAGRAM



MAXIMUM RATINGS

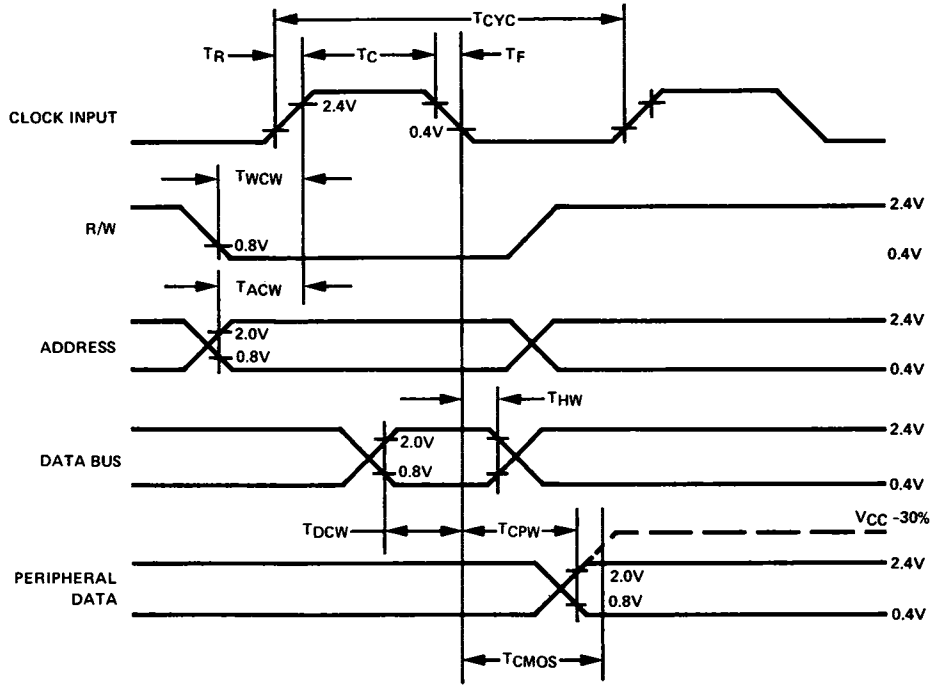
RATING	SYMBOL	VOLTAGE	UNIT
Supply Voltage	V_{CC}	-.3 to +7.0	V
Input/Output Voltage	V_{IN}	-.3 to +7.0	V
Operating Temperature Range	T_{OP}	0 to 70	°C
Storage Temperature Range	T_{STG}	-55 to +150	°C

ELECTRICAL CHARATERISTICS (V_{CC} = 5.0V ±5%, V_{SS} = 0V, T_A = 25° C)

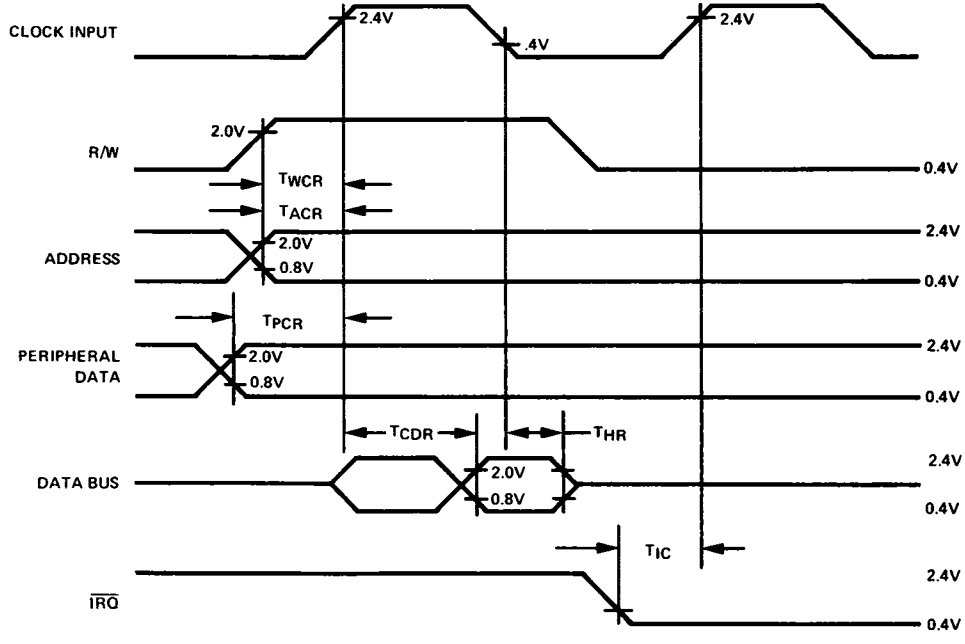
CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
Input High Voltage	V_{IH}	V_{SS} + 2.4		V_{CC}	V
Input Low Voltage	V_{IL}	V_{SS} - .3		V_{SS} + .4	V
Input Leakage Current; V_{IN} = V_{SS} +.5V AØ-A6, $\overline{RS}$, R/W, $\overline{RES}$, Ø2, CS1, $\overline{CS2}$	I_{IN}		1.0	2.5	μA
Input Leakage Current for High Impedance State (Three State); V_{IN} = .4V to 2.4V; DØ-D7	I_{TSI}		±1.0	±10.0	μA
Input High Current; V_{IN} = 2.4V PAØ-PA7, PBØ-PB7	I_{IH}	-100.	-300.		μA
Input Low Current; V_{IN} = .4V PAØ-PA7, PBØ-PB7	I_{IL}		-1.0	-1.6	MA
Output High Voltage V_{CC} = MIN, $I_{LOAD} \leq$ -100μA (PAØ-PA7, PBØ-PB7, DØ-D7) $I_{LOAD} \leq$ 3 MA (PBØ-PB7)	V_{OH}	 V_{SS} + 2.4 V_{SS} + 1.5			V
Output Low Voltage V_{CC} = MIN, $I_{LOAD} \leq$ 1.6MA	V_{OL}			V_{SS} + .4	V
Output High Current (Sourcing); $V_{OH} \geq$ 2.4V (PAØ-PA7, PBØ-PB7, DØ-D7) $\geq$ 1.5V Available for direct transistor drive (PBØ-PB7)	I_{OH}	 -100 3.0	 -1000 5.0		 μA MA
Output Low Current (Sinking); $V_{OL} \leq$ .4V	I_{OL}	1.6			MA
Clock Input Capacitance	C_{Clk}			30	pf
Input Capacitance	C_{IN}			10	pf
Output Capacitance	C_{OUT}			10	pf
Power Dissipation	I_{CC}		100	125	mA

All inputs contain protection circuitry to prevent damage due to high static charges. Care should be exercised to prevent unnecessary application of voltage outside the specification range.

WRITE TIMING CHARACTERISTICS



READ TIMING CHARACTERISTICS



WRITE TIMING CHARACTERISTICS

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
Clock Period	T_{CYC}	1			μS
Rise & Fall Times	TR, TF			25	NS
Clock Pulse Width	TC	470			NS
R/W valid before positive transition of clock	TWCW	180			NS
Address valid before positive transition of clock	TACW	180			NS
Data Bus valid before negative transition of clock	TDCW	300			NS
Data Bus Hold Time	THW	10			NS
Peripheral data valid after negative transition of clock	TCPW			1	μS
Peripheral data valid after negative transition of clock driving CMOS (Level = V_{CC} = 30%)	TCMOS			2	μS

READ TIMING CHARACTERISTICS

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT
R/W valid after positive transition of clock	TWCR	180			NS
Address valid before positive transition of clock	TACR	180			NS
Peripheral data valid before positive transition of clock	TPCR	300			NS
Data Bus valid after positive transition of clock	TCDR			395	NS
Data Bus Hold Time	THR	10			NS
$\overline{IRQ}$ (Interval Timer Interrupt) valid before positive transition of clock	TIC	200			NS

Loading = 30 pf + 1 TTL load for PAØ-PA7, PBØ-PB7
= 130 pf + 1 TTL load for DØ-D7

INTERFACE SIGNAL DESCRIPTION

Reset ($\overline{RES}$)

During system initialization a Logic "0" on the $\overline{RES}$ input will cause a zeroing of all four I/O registers. This in turn will cause all I/O buses to act as inputs thus protecting external components from possible damage and erroneous data while the system is being configured under software control. The Data Bus Buffers are put into an OFF-STATE during Reset. Interrupt capability is disabled with the $\overline{RES}$ signal. The $\overline{RES}$ signal must be held low for at least one clock period when reset is required.

Input Clock

The input clock is a system Phase Two clock which can be either a low level clock ($V_{IL} < 0.4$, $V_{IH} > 2.4$) or high level clock ($V_{IL} < 0.2$, $V_{IH} = Vcc \pm^{.3}_{.2}$).

Read/Write (R/W)

The R/W signal is supplied by the microprocessor array and is used to control the transfer of data to and from the microprocessor array and the SY6532. A high on the R/W pin allows the processor to read (with proper addressing) the data supplied by the SY6532. A low on the R/W pin allows a write (with proper addressing) to the SY6532.

Interrupt Request ($\overline{IRQ}$)

The $\overline{IRQ}$ pin is an interrupt pin from the interrupt control logic. It will be normally high with a low indicating an interrupt from the SY6532. $\overline{IRQ}$ is an open-drain output, permitting several units to be wire-or'ed to the common $\overline{IRQ}$ microprocessor input pin. The $\overline{IRQ}$ pin may be activated by a transition on PA7 or timeout of the interval timer.

Data Bus (D0-D7)

The SY6532 has eight bi-directional data pins (D0-D7). These pins connect to the system's data lines and allow transfer of data to and from the microprocessor array. The output buffers remain in the off state except when a Read operation occurs.

Peripheral Data Ports

The SY6532 has 16 pins available for peripheral I/O operations. Each pin is individually programmable to act as either an input or an output. The 16 pins are divided into two 8-bit ports, PA0-PA7 and PB0-PB7. PA7 may also function as an interrupt input pin. This feature is described in another section. The pins are set up as an input by writing a "0" into the corresponding bit of the data direction register. A "1" into the data direction register will cause its corresponding bit to be an output. When in the input mode, the peripheral output buffers are in the "1" state and a pull-up device acts as less than one TTL load to the peripheral data lines. On a Read operation, the microprocessor unit reads the peripheral pin. When the peripheral device gets information from the SY6532 it receives data stored in the data register. The microprocessor will read correct information if the peripheral lines are greater than 2.4 volts for a "1" and less than 0.4 volts for a "0" as the peripheral pins are all TTL compatible. Pins PB0-PB7 are also capable of sourcing 3 ma at 1.5 v thus making them capable of direct transistor drive.

Address Lines (A0-A6)

There are 7 address pins. In addition to these, there is the $\overline{RS}$ pin. The above pins, A0-A6 and $\overline{RS}$, are always used as addressing pins. There are 2 additional pins which are used as CHIP SELECTS. They are pins CS1 and $\overline{CS2}$.

INTERNAL ORGANIZATION

A block diagram of the internal architecture is shown in Figure 1. The SY6532 is divided into four basic sections: RAM, I/O, Timer, and Interrupt Control. The RAM interfaces directly with the microprocessor through the system data bus and address lines. The I/O section consists of two 8-bit halves. Each half contains a Data Direction Register (DDR) and an I/O register.

RAM 128 Bytes (1024 Bits)

A 128 x 8 static RAM is contained on the SY6532. It is addressed by A0-A6 (Byte Select), $\overline{RS}$, CS1, and $\overline{CS2}$.

Internal Peripheral Registers

There are four 8-bit internal registers: two data direction registers and two output registers. The two data direction registers (A side and B side) control the direction of data into and out of the peripheral I/O pins. A logic zero in a bit of the data direction register (DDRA and DDRB) causes the corresponding pin of the I/O port to act as an input. A logic one causes the corresponding pin to act as an output. The voltage on any pin programmed as an output is determined by the corresponding bit in the output register (ORA and ORB).

Data is read directly from the PA pins during a peripheral read operation. Thus, for a PA pin programmed as an output, the data transferred into the processor will be the same as the data in the ORA only if the voltage on the pin is allowed to be $\geqslant$ 2.4 volts for a logic one and $\leqslant$ 0.4 volts for a zero. If the loading on the pin does not allow this, then the data resulting from the read operation may not match the contents of ORA.

The output buffers for the PB pins are somewhat different from the PA buffers. The PB buffers are push-pull devices which are capable of sourcing 3ma at 1.5 volts. This allows for these pins to directly drive transistor circuits. To assure that the processor will read the proper data when performing a peripheral read operation, logic is provided in the peripheral B port to permit the processor to read the contents of ORB, instead of the PB pins as is the case for the PA port.

Interval Timer

The timer section of the SY6532 contains three basic parts: preliminary divide down register, programmable 8-bit register and interrupt logic. These are illustrated in Figure 2.

The interval timer can be programmed to count up to 256 time intervals. Each time interval can be either 1T, 8T, 64T or 1024T increments, where T is the system clock period. When a full count is reached, and interrupt flag is set to a logic "1." After the interrupt flag is set the internal clock begins counting down to a maximum of -255T. Thus, after the interrupt flag is set, a Read of the timer will tell how long since the flag was set up to a maximum of 255T.

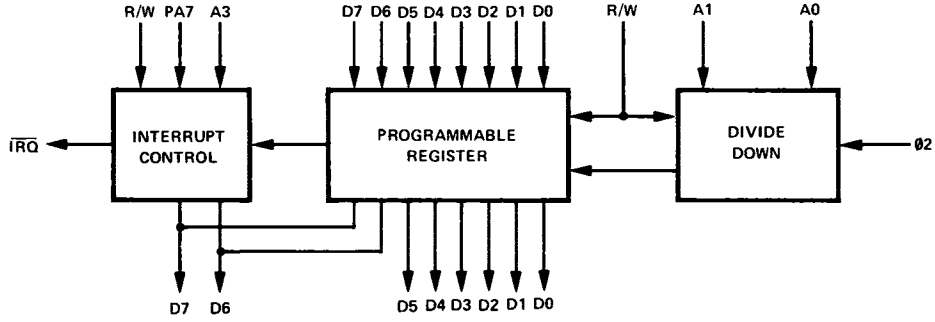
The 8-bit system Data Bus is used to transfer data to and from the Interval Timer. If a count of 52 time intervals were to be counted, the pattern 0 0 1 1 0 1 0 0 would be put on the Data Bus and written into the Interval Time register.

At the same time that data is being written to the Interval Timer, the counting intervals of 1, 8, 64, 1024T are decoded from address lines A0 and A1. During a Read or Write operation address line A3 controls the interrupt capability of $\overline{IRQ}$, i.e., $A_3 = 1$ enables $\overline{IRQ}$, $A_3 = 0$ disables $\overline{IRQ}$. In either case, when timeout occurs, bit 7 of the Interrupt Flag Register is set. This flag is cleared when the Timer register is either read from or written to by the processor. If $\overline{IRQ}$ is enabled by A3 and an interrupt occurs $\overline{IRQ}$ will go low. When the timer is read prior to the interrupt flag being set, the number of time intervals remaining will be read, i.e., 51, 50, 49, etc.

When the timer has counted down to 0 0 0 0 0 0 0 0 on the next count time an interrupt will occur and the counter will read 1 1 1 1 1 1 1 1. After interrupt, the timer register decrements at a divide by "1" rate of the system clock. If after interrupt, the timer is read and a value of 1 1 1 0 0 1 0 0 is read, the time since interrupt is 28T. The value read is in two's complement.

Value read	= 1 1 1 0 0 1 0 0
Complement	= 0 0 0 1 1 0 1 1
Add 1	= 0 0 0 1 1 1 0 0 = 28.

Figure 2. BASIC ELEMENTS OF INTERVAL TIMER

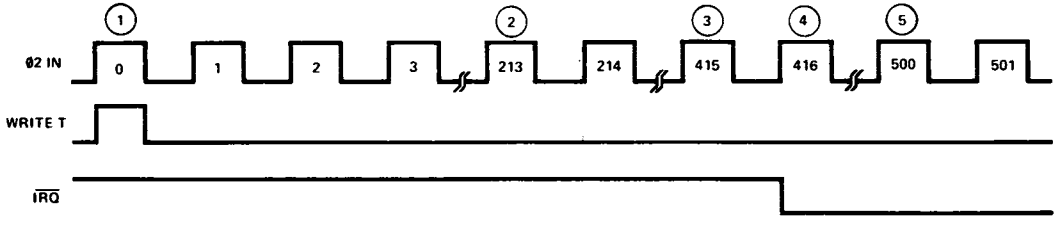


Thus, to arrive at the total elapsed time, merely do a two's complement add to the original time written into the timer. Again, assume time written as 0 0 1 1 0 1 0 0 (=52). With a divide by 8, total time to interrupt is (52 x 8) + 1 = 417T. Total elapsed time would be 416T + 28T = 444T, assuming the value read after interrupt was 1 1 1 0 0 1 0 0.

After interrupt, whenever the timer is written or read the interrupt is reset. However, the reading of the timer at the same time the interrupt occurs will not reset the interrupt flag.

Figure 3 illustrates an example of interrupt.

Figure 3. TIMER INTERRUPT TIMING



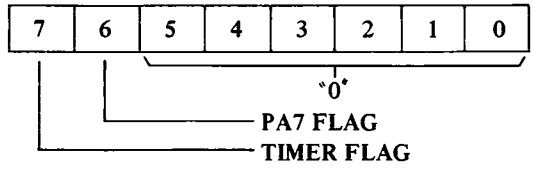
1. Data written into interval timers is $0\,0\,1\,1\,0\,1\,0\,0 = 52_{10}$
2. Data in Interval timer is $0\,0\,0\,1\,1\,0\,0\,1 = 25_{10}$
   $52 - \frac{213}{8} - 1 = 52\text{-}26\text{-}1 = 25$
3. Data in Interval timer is $0\,0\,0\,0\,0\,0\,0\,0 = 0_{10}$
   $52 - \frac{415}{8} - 1 = 52\text{-}51\text{-}1 = 0$
4. Interrupt has occurred at Ø2 pulse #416
   Data in Interval timer = 1 1 1 1 1 1 1 1
5. Data in Interval timer is 1 0 1 0 1 1 0 0
   two's complement is $0\,1\,0\,1\,0\,1\,0\,0 = 84_{10}$
   $84 + (52 \times 8) = 500_{10}$

When reading the timer after an interrupt, A3 should be low so as to disable the $\overline{IRQ}$ pin. This is done so as to avoid future interrupts until after another Write operation.

Interrupt Flag Register

The Interrupt Flag Register consists of two bits: the timer interrupt flag and the PA7 interrupt flag. When a read operation is performed on the Interrupt Flag Register, the bits are transferred to the processor on the data bus, as the diagram below, indicates.

Figure 4. INTERRUPT FLAG REGISTER



The PA7 flag is cleared when the Interrupt Flag Register is read. The timer flag is cleared when the timer register is either written or read.

ADDRESSING

Addressing of the SY6532 is accomplished by the 7 addressing pins, the $\overline{RS}$ pin and the two chip select pins CS1 and $\overline{CS2}$. To address the RAM, CS1 must be high with $\overline{CS2}$ and $\overline{RS}$ low. To address the I/O and Interval timer CS1 and $\overline{RS}$ must be high with $\overline{CS2}$ low. As can be seen to access the chip CS1 is high and $\overline{CS2}$ is low. To distinguish between RAM or I/O Timer the $\overline{RS}$ pin is used. When this pin is low the RAM is addressed, when high the I/O Interval timer section is addressed. To distinguish between timer and I/O address line A2 is utilized. When A2 is high the interval timer is accessed. When A2 is low the I/O section is addressed. Table 1 illustrates the chip addressing.

Edge Sense Interrupt

In addition to its use as a peripheral I/O line, the PA7 pin can function as an edge sensitive input. In this mode, an active transition on PA7 will set the internal interrupt flag (bit 6 of the Interrupt Flag Register). When this occurs, and providing the PA7 interrupt is enabled, the $\overline{IRQ}$ output will go low.

Control of the PA7 edge detecting logic is accomplished by performing a write operation to one of four addresses. The data lines for this operation are "don't care" and the addresses to be used are found in Figure 4.

The setting of the internal Interrupt flag by an active transition on PA7 is always enabled, no matter whether PA7 is set up as an input or an output.

The $\overline{RES}$ signal disables the PA7 interrupt and sets the active transition to the negative edge-detect state. During the reset operation, the interrupt flag may be set by a negative transition. It may, therefore, be necessary to clear the flag before its normal use as an edge detecting input is enabled. This can be achieved by reading the Interrupt Flag Register, as defined by Figure 4 immediately after reset.

I/O Register - Timer Addressing

Table 1 illustrates the address decoding for the internal elements and timer programming. Address line A2 distinguishes I/O registers from the timer. When A2 is low and $\overline{RS}$ is high, the I/O registers are addressed. Once the I/O registers are addressed, address lines A1 and A0 decode the desired register.

When the timer is selected A1 and A0 decode the "divide-by" matrix. This decoding is defined in Table 1. In addition, Address A3 is used to enable the interrupt flag to $\overline{IRQ}$.

Table 1 ADDRESSING DECODE

OPERATION	$\overline{RS}$	R/W	A4	A3	A2	A1	A0
Write RAM	0	0	–	–	–	–	–
Read RAM	0	1	–	–	–	–	–
Write DDRA	1	0	–	–	0	0	1
Read DDRA	1	1	–	–	0	0	1
Write DDRB	1	0	–	–	0	1	1
Read DDRB	1	1	–	–	0	1	1
Write Output Reg A	1	0	–	–	0	0	0
Read Output Reg A	1	1	–	–	0	0	0
Write Output Reg B	1	0	–	–	0	1	0
Read Output Reg B	1	1	–	–	0	1	0
Write Timer							
÷ 1T	1	0	1	(a)	1	0	0
÷ 8T	1	0	1	(a)	1	0	1
÷ 64T	1	0	1	(a)	1	1	0
÷ 1024T	1	0	1	(a)	1	1	1
Read Timer	1	1	–	(a)	1	–	0
Read Interrupt Flag	1	1	–	–	1	–	1
Write Edge Detect Control	1	0	0	–	1	(b)	(c)

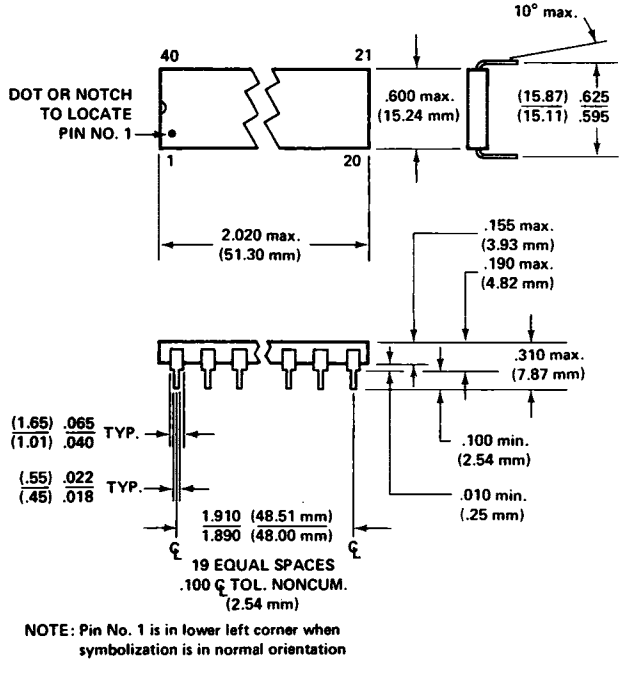
NOTES: – = Don't Care, "1" = High level (≥2.4V), "0" = Low level (≤0.4V)

(a) A3 = 0 to disable interrupt from timer to $\overline{IRQ}$
A3 = 1 to enable interrupt from timer to $\overline{IRQ}$

(b) A1 = 0 to disable interrupt from PA7 to $\overline{IRQ}$
A1 = 1 to enable interrupt from PA7 to $\overline{IRQ}$

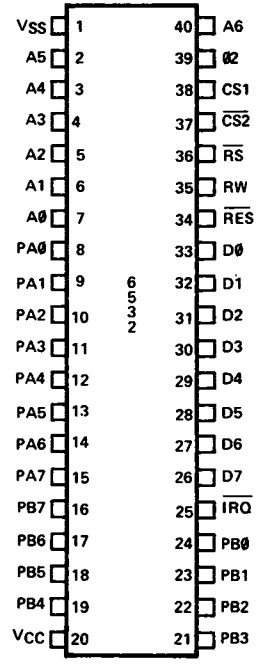
(c) A0 = 0 for negative edge-detect
A0 = 1 for positive edge-detect

PACKAGE OUTLINE



NOTE: Pin No. 1 is in lower left corner when symbolization is in normal orientation

PIN DESIGNATION



APPENDIX J

SY2114 RAM DATA SHEET

1024x4 Static Random Access Memory

SY2114

MEMORY PRODUCTS

Synertek®

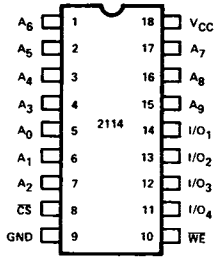
- 300 ns Maximum Access
- Low Operating Power Dissipation 0.1 mW/Bit
- No Clocks or Strobes Required
- Identical Cycle and Access Times
- Single +5V Supply
- Totally TTL Compatible: All Inputs, Outputs, and Power Supply
- Common Data I/O
- 400 mv Noise Immunity
- High Density 18 Pin Package

The SY2114 is a 4096-Bit static Random Access Memory organized 1024 words by 4-bits and is fabricated using Synertek's N-channel Silicon-Gate MOS technology. It is designed using fully DC stable (static) circuitry in both the memory array and the decoding and therefore requires no clock or refreshing to operate. Address setup times are not required and the data is read out nondestructively with the same polarity as the input data. Common Input/Output pins are provided to simplify design of the bus oriented systems, and can drive 2 TTL loads.

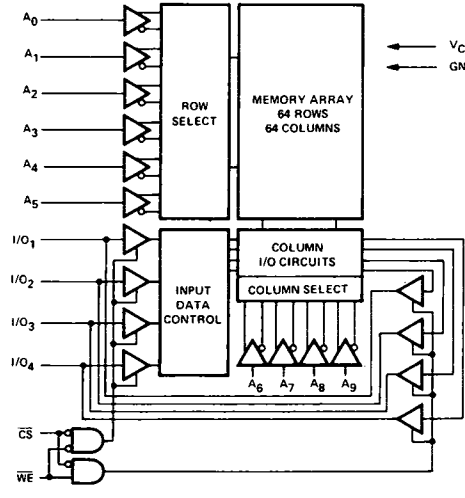
The SY2114 is designed for memory applications where high performance, low cost, large bit storage, and simple interfacing are important design objectives. It is totally TTL compatible in all respects: inputs, outputs, and the single +5V supply. A separate Chip Select ($\overline{CS}$) input allows easy selection of an individual device when outputs are or-tied.

The SY2114 is packaged in an 18-pin DIP for the highest possible density and is fabricated with N-channel, Ion Implanted, Silicon-Gate technology – a technology providing excellent performance characteristics as well as protection against contamination allowing the use of low cost packaging techniques.

PIN CONFIGURATION



BLOCK DIAGRAM



ORDERING INFORMATION

Order Number	Package Type	Access Time	Supply Current (Max)	Temperature Range
SYC2114	Ceramic	450nsec	100mamp	0°C to 70°C
SYP2114	Molded	450nsec	100mamp	0°C to 70°C
SYC2114-3	Ceramic	300nsec	100mamp	0°C to 70°C
SYP2114-3	Molded	300nsec	100mamp	0°C to 70°C
SYC2114L	Ceramic	450nsec	70mamp	0°C to 70°C
SYP2114L	Molded	450nsec	70mamp	0°C to 70°C
SYC2114L-3	Ceramic	300nsec	70mamp	0°C to 70°C
SYP2114L-3	Molded	300nsec	70mamp	0°C to 70°C

ABSOLUTE MAXIMUM RATINGS

Temperature Under Bias	-10°C to 80°C
Storage Temperature	-65°C to 150°C
Voltage on Any Pin with Respect to Ground	-0.5V to +7V
Power Dissipation	1.0W

COMMENT

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

D.C. CHARACTERISTICS $T_A = 0°C$ to $+70°C$, $V_{CC} = 5V \pm 5\%$ (Unless Otherwise Specified)

Symbol	Parameter	2114-3, 2114 Min	2114-3, 2114 Max	2114L, 2114L-3 Min	2114L, 2114L-3 Max	Unit	Conditions
I_{LI}	Input Load Current (All input pins)		10		10	μA	V_{IN} = 0 to 5.25V
I_{LO}	I/O Leakage Current		10		10	μA	$\overline{CS}$ = 2.0V, $V_{I/O}$ = 0.4V to V_{CC}
I_{CC1}	Power Supply Current		95		65	mA	V_{CC} = 5.25V, $I_{I/O}$ = 0 mA, T_A = 25°C
I_{CC2}	Power Supply Current		100		70	mA	V_{CC} = 5.25V, $I_{I/O}$ = 0 mA, T_A = 0°C
V_{IL}	Input Low Voltage	-0.5	0.8	-0.5	0.8	V	
V_{IH}	Input High Voltage	2.0	V_{CC}	2.0	V_{CC}	V	
V_{OL}	Output Low Voltage		0.4		0.4	V	I_{OL} = 3.2 mA
V_{OH}	Output High Voltage	2.4	V_{CC}	2.4	V_{CC}	V	I_{OH} = -1.0 mA

CAPACITANCE $T_A = 25°C$, f = 1.0 MHz

Symbol	Test	Typ	Max	Units
$C_{I/O}$	Input/Output Capacitance		5	pF
C_{IN}	Input Capacitance		5	pF

NOTE: This parameter is periodically sampled and not 100% tested.

A.C. CHARACTERISTICS $T_A = 0°C$ to $70°C$, $V_{CC} = 5V \pm 5\%$ (Unless Otherwise Specified)

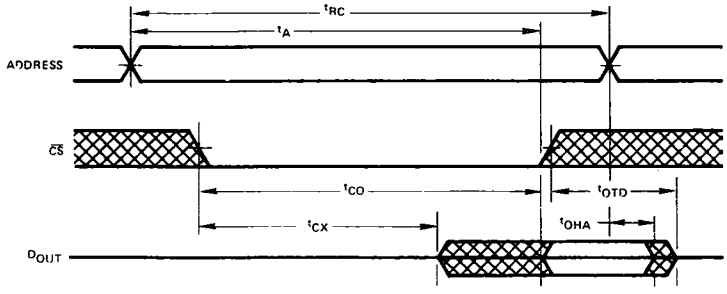
SYMBOL	PARAMETER	2114-3,2114L-3 MIN	2114-3,2114L-3 MAX	2114, 2114L MIN	2114, 2114L MAX	UNIT
READ CYCLE						
t_{RC}	Read Cycle Time	300		450		nsec
t_A	Access Time		300		450	nsec
t_{CO}	Chip Select to Output Valid		100		120	nsec
t_{CX}	Chip Select to Output Enabled	20		20		nsec
t_{OTD}	Chip Deselect to Output Off	0	80	0	100	nsec
t_{OHA}	Output Hold From Address Change	50		50		nsec
WRITE CYCLE						
t_{WC}	Write Cycle Time	300		450		nsec
t_{AW}	Address to Write Setup Time	0		0		nsec
t_W	Write Pulse Width	150		200		nsec
t_{WR}	Write Release Time	0		0		nsec
t_{OTW}	Write to Output Off	0	80	0	100	nsec
t_{DW}	Data to Write Overlap	150		200		nsec
t_{DH}	Data Hold	0		0		nsec

A.C. Test Conditions

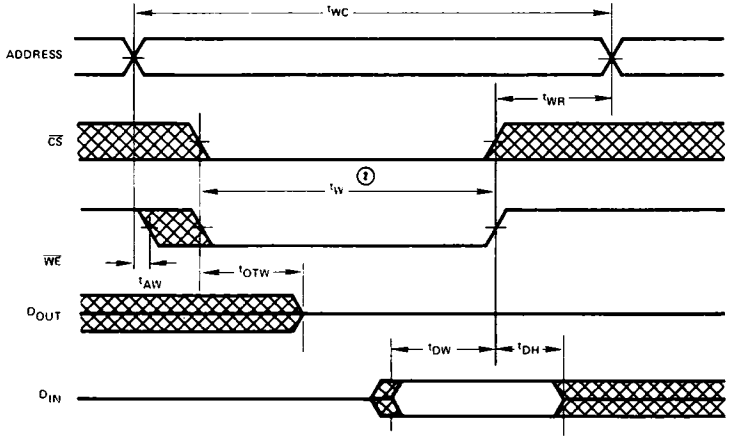
Input Pulse Levels . . . . . 0.8V to 2.0V
Input Rise and Fall Time . . . . . 10 n sec
Timing Measurement Levels: Input 1.5V
Output . . . . . 0.8 and 2.0V
Output Load . . . . . 1TTL Gate and 100pF

TIMING DIAGRAMS

Read Cycle ①



Write Cycle



NOTES:

① $\overline{WE}$ is high for a Read Cycle

② t_W is measured from the latter of $\overline{CS}$ or $\overline{WE}$ going low to the earlier of $\overline{CS}$ or $\overline{WE}$ going high.

DATA STORAGE

When $\overline{WE}$ is high, the data input buffers are inhibited to prevent erroneous data from being written into the array. As long as $\overline{WE}$ remains high, the data stored cannot be affected by the Address, Chip Select, or Data I/O logic levels or timing transitions.

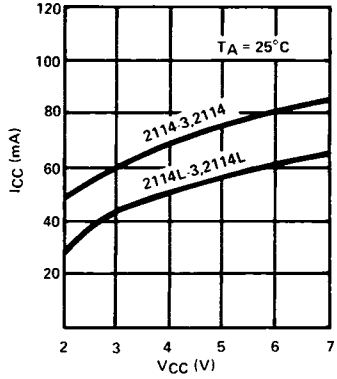
Data storage also cannot be affected by $\overline{WE}$, Addresses, or the I/O ports as long as $\overline{CS}$ is high. Either $\overline{CS}$ or $\overline{WE}$ or both can prevent extraneous writing due to signal transitions.

Data within the array can only be changed during Write time – defined as the overlap of $\overline{CS}$ low and $\overline{WE}$ low. The addresses must be properly established during the entire Write time plus t_{WR}.

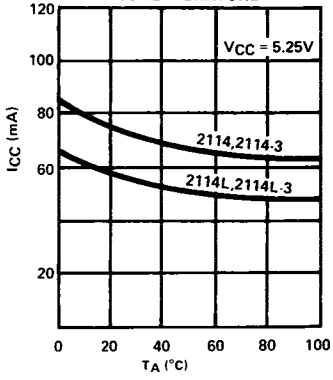
Internal delays are such that address decoding propagates ahead of data inputs and therefore no address setup time is required. If the Write time precedes the addresses, the data in previously addressed locations, or some other location, may be changed. Addresses must remain stable for the entire Write cycle but the Data Inputs may change. The data which is stable for t_{DW} at the end of the Write time will be written into the addressed location.

TYPICAL CHARACTERISTICS

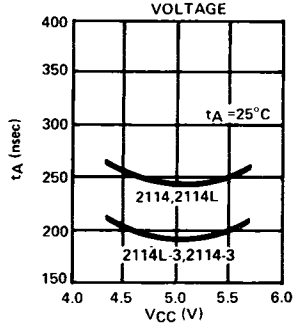
SUPPLY CURRENT VS VOLTAGE



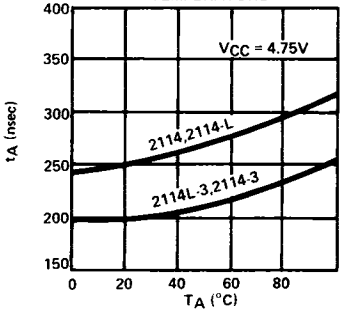
SUPPLY CURRENT VS TEMPERATURE



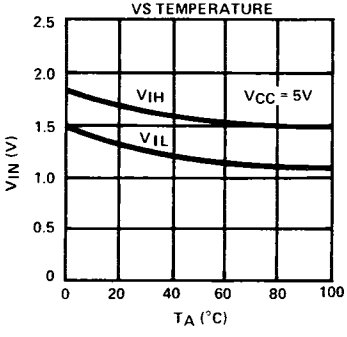
ACCESS TIME VS VOLTAGE



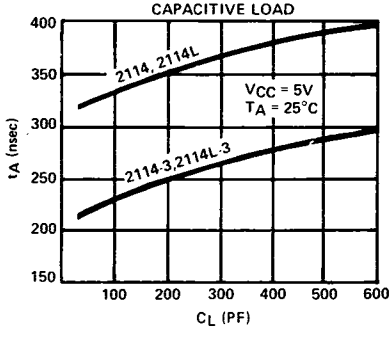
ACCESS TIME VS TEMPERATURE



INPUT VOLTAGE LIMITS VS TEMPERATURE

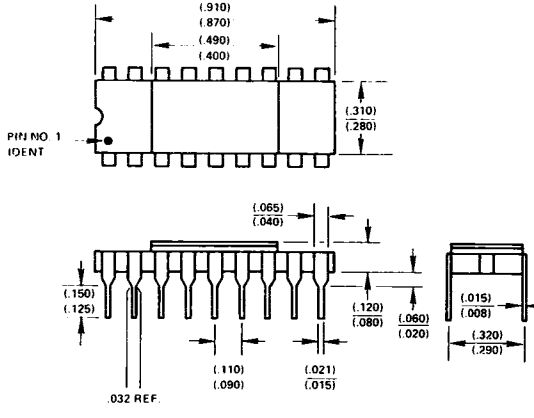


ACCESS TIME VS CAPACITIVE LOAD

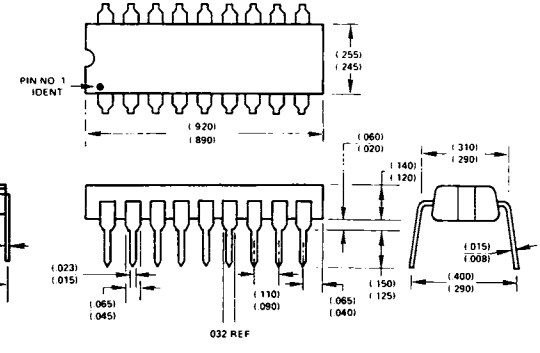


PACKAGE DIAGRAM

CERAMIC PACKAGE



MOLDED PACKAGE



VIM SUPERMON Monitor Listing

```
LINE # LOC     CODE       LINE

0002  0000              ;
0003  0000              ;*****
0004  0000              ;***** COPYRIGHT 1978 SYNERTEK SYSTEMS CORPORATION
0005  0000              ;*****
0006  0000                      *=$A600          ;SYS RAM (ECHOED AT TOP OF MEM)
0007  A600              SCPBUF  *=*+$20          ;SCOPE BUFFER LAST 32 CHRS
0008  A620              RAM     =*               ;DEFAULT BLK FILLS STARTING HERE
0009  A620              JTABLE  *=*+$10          ; 8JUMPS - ABS ADDR, LO HI ORDER
0010  A630              SCR0    *=*+1            ;RAM SCRATCH LOCS 0-F
0011  A631              SCR1    *=*+1
0012  A632              SCR2    *=*+1
0013  A633              SCR3    *=*+1
0014  A634              SCR4    *=*+1
0015  A635              SCR5    *=*+1
0016  A636              SCR6    *=*+1
0017  A637              SCR7    *=*+1
0018  A638              SCR8    *=*+1
0019  A639              SCR9    *=*+1
0020  A63A              SCRA    *=*+1
0021  A63B              SCRB    *=*+1
0022  A63C              SCRC    *=*+1
0023  A63D              SCRD    *=*+1
0024  A63E              RC      =SCRD
0025  A63E              SCRE    *=*+1
0026  A63F              SCRF    *=*+1
0027  A640              DISBUF  *=*+5            ;DISPLAY BUFFER
0028  A645              RDIG    *=*+1            ;RIGHT MOST DIGIT OF DISPLAY
0029  A646                      *=*+3            ;NOT USED
0030  A649              PARNR   *=*+1            ;NUMBER OF PARMS RECEIVED
0031  A64A              ;
0032  A64A              ; 3 16 BIT PARMS, LO HI ORDER
0033  A64A              ; PASSED TO EXECUTE BLOCKS
0034  A64A              ;
0035  A64A              P3L     *=*+1
0036  A64B              P3H     *=*+1
0037  A64C              P2L     *=*+1
0038  A64D              P2H     *=*+1
0039  A64E              P1L     *=*+1
0040  A64F              P1H     *=*+1
0041  A650              PADBIT  *=*+1            ;PAD BITS FOR CARRIAGE RETURN
0042  A651              SDBYT   *=*+1            ;SPEED BYTE FOR TERMINAL I/O
0043  A652              ERCNT   *=*+1            ; ERROR COUNT  (MAX $FF)
0044  A653              ; BIT 7   ECHO /NO ECHO, BIT 6 = CTL O TOGGLE SW
0045  A653              TECHO   *=*+1            ;TERMINAL ECHO FLAG
0046  A654              ; BIT7 =CRT IN, 6 =TTY IN, 5 = TTY OUT, 4 = CRT OUT
0047  A654              TOUTFL  *=*+1            ;OUTPUT FLAGS
0048  A655              KSHFL   *=*+1            ;KEYBOARD SHIFT FLAG
0049  A656              TV      *=*+1            ;TRACE VELOCITY (0=SINGLE STEP)
0050  A657              LSTCOM  *=*+1            ;STORE LAST MONITOR COMMAND
0051  A658              MAXRC   *=*+1            ;MAX REC LENGTH FOR MEM DUMP
0052  A659              ;
0053  A659              ; USER REG'S FOLLOW
0054  A659              ;
0055  A659              PCLR    *=*+1            ;PROG CTR
0056  A65A              PCHR    *=*+1
```

```
LINE # LOC      CODE        LINE

0057  A65B                SR      *=*+1           ;STACK
0058  A65C                FR      *=*+1           ;FLAGS
0059  A65D                AR      *=*+1           ;AREG
0060  A65E                XR      *=*+1           ;XREG
0061  A65F                YR      *=*+1           ;YREG
0062  A660                ;
0063  A660                ; I/O VECTORS FOLLOW
0064  A660                ;
0065  A660                INVEC   *=*+3           ;IN CHAR
0066  A663                OUTVEC  *=*+3           ;OUT CHAR
0067  A666                INSVEC  *=*+3           ;IN STATUS
0068  A669                        *=*+3           ;NOT USED
0069  A66C                URCVEC  *=*+3           ;UNRECOGNIZED CMD/ERROR VECTOR
0070  A66F                SCNVEC  *=*+3           ;SCAN ON-BOARD DISPLAY
0071  A672                ;
0072  A672                ; TRACE, INTERRUPT VECTORS
0073  A672                ;
0074  A672                EXEVEC  *=*+2           ; EXEC CMD ALTERNATE INVEC
0075  A674                TRCVEC  *=*+2           ;TRACE
0076  A676                UBRKVC  *=*+2           ;USER BRK AFTER MONITOR
0077  A678                UBRKV   =UBRKVC
0078  A678                UIRQVC  *=*+2           ;USER NON-BRK IRQ AFTER MONITOR
0079  A67A                UIRQV   =UIRQVC
0080  A67A                NMIVEC  *=*+2           ;NMI
0081  A67C                RSTVEC  *=*+2           ;RESET
0082  A67E                IRQVEC  *=*+2           ;IRQ
0083  A680                ;
0084  A680                ;
0085  A680                                        ;I/O REG DEFINITIONS
0086  A680                PADA    =$A400          ;KEYBOARD/DISPLAY
0087  A680                PBDA    =$A402          ;DATA DIRECTION FOR SAME
0088  A680                OR3A=$AC01              ;WP, DBON, DBOFF
0089  A680                DDR3A=OR3A+2            ;DATA DIRECTION FOR SAME
0090  A680                OR1B=$A000
0091  A680                DDR1B=$A002
0092  A680                PCR1    =$A00C          ; POR/TAPE REMOTE
0093  A680                ;
0094  A680                ; MONITOR MAINLINE
0095  A680                ;
0096  A680                        *=$8000
0097  8000  4C 7C 8B     MONITR JMP MONENT       ;INIT S, CLD, GET ACCESS
0098  8003  20 FF 80     WARM    JSR GETCOM      ;GET COMMAND + PARMS  (0-3)
0099  8006  20 4A 81             JSR DISPAT      ;DISPATCH CMD,PARMS TO EXEC BLKS
0100  8009  20 71 81             JSR ERMSG       ;DISP ER MSG IF CARRY SET
0101  800C  4C 03 80             JMP WARM        ;AND CONTINUE
0102  800F                ;
0103  800F                ; TRACE AND INTERRUPT ROUTINES
0104  800F                ;
0105  800F  08           IRQBRK PHP              ;IRQ OR BRK ?
0106  8010  48                   PHA
0107  8011  8A                   TXA
0108  8012  48                   PHA
0109  8013  BA                   TSX
0110  8014  BD 04 01             LDA $104,X      ;PICK UP FLAGS
0111  8017  29 10               AND #$10
```

```
LINE # LOC      CODE        LINE

0112  8019  F0 07             BEQ DETIRQ
0113  801B  68          DETBRK PLA              ;BRK
0114  801C  AA                 TAX
0115  801D  68                 PLA
0116  801E  28                 PLP
0117  801F  6C F6 FF           JMP ($FFF6)
0118  8022  68          DETIRQ PLA              ;IRQ (NON BRK)
0119  8023  AA                 TAX
0120  8024  68                 PLA
0121  8025  28                 PLP
0122  8026  6C F8 FF           JMP ($FFF8)
0123  8029  20 86 8B    SVIRQ  JSR ACCESS       ;SAVE REGS AND DISPLAY CODE
0124  802C  38                 SEC
0125  802D  20 64 80           JSR SAVINT
0126  8030  A9 31               LDA #'1
0127  8032  4C 53 80           JMP IDISP
0128  8035  08          USRENT PHP              ;USER ENTRY
0129  8036  20 86 8B           JSR ACCESS
0130  8039  38                 SEC
0131  803A  20 64 80           JSR SAVINT
0132  803D  EE 59 A6           INC PCLR
0133  8040  D0 03              BNE *+5
0134  8042  EE 5A A6           INC PCHR
0135  8045  A9 33               LDA #'3
0136  8047  4C 53 80           JMP IDISP
0137  804A  20 86 8B    SVBRK  JSR ACCESS
0138  804D  18                 CLC
0139  804E  20 64 80           JSR SAVINT
0140  8051  A9 30               LDA #'0
0141  8053                ; INTRPT CODES      ;0 = BRK
0142  8053                ;                   1 = IRQ
0143  8053                ;                   2 = NMI
0144  8053                ;                   3 = USER ENTRY
0145  8053  48          IDISP  PHA                  ;OUT PC, INTRPT CODE (FROM A
0146  8054  20 D3 80           JSR DBOFF           ;STOP NMI'S
0147  8057  20 4D 83           JSR CRLF
0148  805A  20 37 83           JSR OPCCOM
0149  805D  68                 PLA
0150  805E  20 47 8A           JSR OUTCHR
0151  8061  4C 03 80           JMP WARM
0152  8064  8D 5D A6    SAVINT STA AR              ;SAVE USER REGS AFTER INTRPT
0153  8067  8E 5E A6           STX XR
0154  806A  8C 5F A6           STY YR
0155  806D  BA                 TSX
0156  806E  D8                 CLD
0157  806F  BD 04 01           LDA $104,X
0158  8072  69 FF              ADC #$FF
0159  8074  8D 59 A6           STA PCLR
0160  8077  BD 05 01           LDA $105,X
0161  807A  69 FF              ADC #$FF
0162  807C  8D 5A A6           STA PCHR
0163  807F  BD 03 01           LDA $103,X
0164  8082  8D 5C A6           STA FR
0165  8085  BD 02 01           LDA $102,X
0166  8088  9D 05 01           STA $105,X
```

```
LINE # LOC      CODE        LINE

0167  808B  BD 01 01          LDA $101,X
0168  808E  9D 04 01          STA $104,X
0169  8091  E8                INX
0170  8092  E8                INX
0171  8093  E8                INX
0172  8094  9A                TXS
0173  8095  E8                INX
0174  8096  E8                INX
0175  8097  8E 5B A6          STX SR
0176  809A  60                RTS
0177  809B  20 86 8B    SVNMI  JSR ACCESS       ;TRACE IF TV NE 0
0178  809E  38                SEC
0179  809F  20 64 80          JSR SAVINT
0180  80A2  20 D3 80          JSR DBOFF         ;STOP NMI'S
0181  80A5  AD 56 A6          LDA TV
0182  80A8  D0 05             BNE TVNZ
0183  80AA  A9 32             LDA #'2
0184  80AC  4C 53 80          JMP IDISP
0185  80AF  20 37 83    TVNZ   JSR OPCCOM       ;TRACE WITH DELAY
0186  80B2  AD 5D A6          LDA AR
0187  80B5  20 4A 83          JSR OBCRLF        ;DISPLAY ACC
0188  80B8  20 5A 83          JSR DELAY
0189  80BB  90 10             BCC TRACON        ;STOP IF KEY ENTERED
0190  80BD  4C 03 80          JMP WARM
0191  80C0  20 86 8B    TRCOFF JSR ACCESS       ;DISABLE NMIS
0192  80C3  38                SEC
0193  80C4  20 64 80          JSR SAVINT
0194  80C7  20 D3 80          JSR DBOFF
0195  80CA  6C 74 A6          JMP (TRCVEC) AND GO TO SPECIAL TRACE
0196  80CD  20 E4 80    TRACON JSR DBON         ;ENABLE NMI'S
0197  80D0  4C FA 83          JMP GO1ENT        ;AND RESUME
0198  80D3  AD 01 AC    DBOFF  LDA OR3A         ;PULSE DEBUG OFF
0199  80D6  29 DF             AND #$DF
0200  80D8  09 10             ORA #$10
0201  80DA  8D 01 AC          STA OR3A
0202  80DD  AD 03 AC          LDA DDR3A
0203  80E0  09 30             ORA #$30
0204  80E2  D0 0F             BNE DBNEW-3       ;RELEASE FLIP FLOP SO KEY WORKS
0205  80E4  AD 01 AC    DBON   LDA OR3A         ;PULSE DEBUG ON
0206  80E7  29 EF             AND #$EF
0207  80E9  09 20             ORA #$20
0208  80EB  8D 01 AC          STA OR3A
0209  80EE  AD 03 AC          LDA DDR3A
0210  80F1  09 30             ORA #$30
0211  80F3  8D 03 AC          STA DDR3A
0212  80F6  AD 03 AC    DBNEW  LDA DDR3A        ;RELEASE FLIP FLOP
0213  80F9  29 CF             AND #$CF
0214  80FB  8D 03 AC          STA DDR3A
0215  80FE  60                RTS
0216  80FF                ;
0217  80FF                ; GETCOM - GET COMMAND AND 0-3 PARMS
0218  80FF                ;
0219  80FF  20 4D 83    GETCOM JSR CRLF
0220  8102  A9 2E             LDA #'.         ;PROMPT
0221  8104  20 47 8A          JSR OUTCHR
```

```
LINE # LOC      CODE        LINE

0222  8107  20 1B 8A    GETC1  JSR INCHR
0223  810A  F0 F3               BEQ GETCOM       ;CARRIAGE RETURN?
0224  810C  C9 7F               CMP #$7F         ;DELETE?
0225  810E  F0 F7               BEQ GETC1
0226  8110  C9 00               CMP #0           ;NULL?
0227  8112  F0 F3               BEQ GETC1
0228  8114                    ; L,S,U NEED TO BE HASHED 2 BYTES TO ONE
0229  8114  C9 53               CMP #'S
0230  8116  F0 1B               BEQ HASHUS
0231  8118  C9 55               CMP #'U
0232  811A  F0 17               BEQ HASHUS
0233  811C  C9 4C               CMP #'L
0234  811E  F0 0F               BEQ HASHL
0235  8120  8D 57 A6    STOCOM STA LSTCOM
0236  8123  20 42 83           JSR SPACE
0237  8126  20 08 82           JSR PSHOVE       ;ZERO PARMS
0238  8129  20 08 82           JSR PSHOVE
0239  812C  4C 20 82           JMP PARM         ;AND GO GET PARMS
0240  812F  A9 01       HASHL  LDA #$01         ;HASH LOAD CMDS TO ONE BYTE
0241  8131  10 02               BPL HASHUS+2
0242  8133  0A         HASHUS ASL A            ;HASH 'USER' CMDS TO ONE BYTE A
0243  8134  0A                 ASL A            ;U0 = $14 THRU UZ =$1B
0244  8135  8D 57 A6           STA LSTCOM
0245  8138  20 1B 8A           JSR INCHR        ;GET SECOND
0246  813B  F0 C2               BEQ GETCOM       ;CARRIAGE RETURN?
0247  813D  18                 CLC
0248  813E  6D 57 A6           ADC LSTCOM
0249  8141  29 0F               AND #$0F
0250  8143  09 10               ORA #$10
0251  8145  10 D9               BPL STOCOM
0252  8147  20 1B 8A           JSR INCHR
0253  814A                    ;
0254  814A                    ;DISPATCH TO EXEC BLK 0PARM, 1PARM, 2PARM, OR 3PARM
0255  814A                    ;
0256  814A  C9 0D       DISPAT CMP #$0D         ;C/R IF OK ELSE URCVEC
0257  814C  D0 20               BNE HIPN
0258  814E  AD 57 A6           LDA LSTCOM
0259  8151  AE 49 A6           LDX PARNR
0260  8154  D0 03               BNE M12
0261  8156  4C 95 83           JMP BZPARM       ;0 PARM BLOCK
0262  8159  E0 01       M12    CPX #$01
0263  815B  D0 03               BNE M13
0264  815D  4C DA 84           JMP B1PARM       ;1PARM BLOCK
0265  8160  E0 02       M13    CPX #$02
0266  8162  D0 03               BNE M14
0267  8164  4C 19 86           JMP B2PARM       ;2 PARM BLOCK
0268  8167  E0 03       M14    CPX #$03
0269  8169  D0 03               BNE HIPN
0270  816B  4C 14 87           JMP B3PARM       ;3 PARM BLOCK
0271  816E  6C 6D A6    HIPN   JMP (URCVEC+1)   ;ELSE UNREC COMMAND VECTOR
0272  8171                    ;
0273  8171                    ; ERMSG - PRINT ACC IN HEX IF CARRY SET
0274  8171                    ;
0275  8171  90 44       ERMSG  BCC M15
0276  8173  48                 PHA
```

```
LINE # LOC      CODE        LINE

0277  8174  20 4D 83           JSR CRLF
0278  8177  A9 45              LDA #'E
0279  8179  20 47 8A           JSR OUTCHR
0280  817C  A9 52              LDA #'R
0281  817E  20 47 8A           JSR OUTCHR
0282  8181  20 42 83           JSR SPACE
0283  8184  68                 PLA
0284  8185  4C FA 82           JMP OUTBYT
0285  8188                ;
0286  8188                ; SAVER - SAVE ALL REG'S + FLAGS ON STACK
0287  8188                ; RETURN WITH F,A,X,Y UNCHANGED
0288  8188                ; STACK HAS          FLAGS,A,X,Y PUSHED
0289  8188  08           SAVER  PHP                ;
0290  8189  48                 PHA              ;
0291  818A  48                 PHA              ;
0292  818B  48                 PHA
0293  818C  08                 PHP
0294  818D  48                 PHA
0295  818E  8A                 TXA
0296  818F  48                 PHA
0297  8190  BA                 TSX
0298  8191  BD 09 01           LDA $0109,X
0299  8194  9D 05 01           STA $0105,X
0300  8197  BD 07 01           LDA $0107,X
0301  819A  9D 09 01           STA $0109,X
0302  819D  BD 01 01           LDA $0101,X
0303  81A0  9D 07 01           STA $0107,X
0304  81A3  BD 08 01           LDA $0108,X
0305  81A6  9D 04 01           STA $0104,X
0306  81A9  BD 06 01           LDA $0106,X
0307  81AC  9D 08 01           STA $0108,X
0308  81AF  98                 TYA
0309  81B0  9D 06 01           STA $0106,X
0310  81B3  68                 PLA
0311  81B4  AA                 TAX
0312  81B5  68                 PLA
0313  81B6  28                 PLP
0314  81B7  60           M15    RTS
0315  81B8                ; RESTORE EXCEPT A,F
0316  81B8  08           RESXAF PHP
0317  81B9  BA                 TSX
0318  81BA  9D 04 01           STA $0104,X
0319  81BD  28                 PLP
0320  81BE                ; RESTORE EXCEPT F
0321  81BE  08           RESXF  PHP
0322  81BF  68                 PLA
0323  81C0  BA                 TSX
0324  81C1  9D 04 01           STA $0104,X
0325  81C4                ; RESTORE ALL 100% '
0326  81C4  68           RESALL PLA
0327  81C5  A8                 TAY
0328  81C6  68                 PLA
0329  81C7  AA                 TAX
0330  81C8  68                 PLA
0331  81C9  28                 PLP
```

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LINE # LOC     CODE        LINE

0332  81CA  60              RTS
0333  81CB                  ;
0334  81CB                  ; MONITOR UTILITIES
0335  81CB                  ;
0336  81CB  C9 20        ADVCK  CMP #$20        ;SPACE?
0337  81CD  F0 02              BEQ M1
0338  81CF  C9 3E              CMP #'>        ;FWD ARROW?
0339  81D1  38          M1    SEC
0340  81D2  60              RTS
0341  81D3  20 FA 82    OBCMIN JSR OUTBYT      ;OUT BYTE, OUT COMMA, IN BYTE
0342  81D6  20 3A 83    COMINB JSR COMMA       ;OUT COMMA, IN BYTE
0343  81D9  20 1B 8A    INBYTE JSR INCHR
0344  81DC  20 75 82           JSR ASCNIB
0345  81DF  B0 14              BCS OUT4
0346  81E1  0A                 ASL A
0347  81E2  0A                 ASL A
0348  81E3  0A                 ASL A
0349  81E4  0A                 ASL A
0350  81E5  8D 33 A6           STA SCR3
0351  81E8  20 1B 8A           JSR INCHR
0352  81EB  20 75 82           JSR ASCNIB
0353  81EE  B0 11              BCS OUT2
0354  81F0  0D 33 A6           ORA SCR3
0355  81F3  18          GOOD  CLC
0356  81F4  60                RTS
0357  81F5  C9 27        OUT4  CMP #$27        ;SINGLE TIC ?
0358  81F7  D0 05              BNE OUT1
0359  81F9  20 1B 8A           JSR INCHR
0360  81FC  D0 F5              BNE GOOD        ;CARRIAGE RETURN?
0361  81FE  B8          OUT1  CLV
0362  81FF  50 03              BVC CRCHK
0363  8201  2C 04 82    OUT2  BIT CRCHK
0364  8204  C9 0D        CRCHK CMP #$0D        ;CHECK FOR C/R
0365  8206  38                SEC
0366  8207  60                RTS
0367  8208  A2 10        PSHOVE LDX #$10       ;PUSH PARMS DOWN
0368  820A  0E 4A A6    PRM10 ASL P3L
0369  820D  2E 4B A6           ROL P3H
0370  8210  2E 4C A6           ROL P2L
0371  8213  2E 4D A6           ROL P2H
0372  8216  2E 4E A6           ROL P1L
0373  8219  2E 4F A6           ROL P1H
0374  821C  CA                 DEX
0375  821D  D0 EB              BNE PRM10
0376  821F  60                RTS
0377  8220  20 88 81    PARM  JSR SAVER       ;GET PARMS - RETURN ON C/R OR ERR
0378  8223  A9 00              LDA #0
0379  8225  8D 49 A6           STA PARNR
0380  8228  8D 33 A6           STA SCR3
0381  822B  20 08 82    PM1   JSR PSHOVE
0382  822E  20 1B 8A    PARFIL JSR INCHR
0383  8231  C9 2C              CMP #',        ;VALID DELIMITERS - ,
0384  8233  F0 04              BEQ M21
0385  8235  C9 2D              CMP #'-
0386  8237  D0 11              BNE M22
```

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LINE # LOC      CODE        LINE

0387  8239  A2 FF        M21     LDX #$FF
0388  823B  8E 33 A6              STX SCR3
0389  823E  EE 49 A6              INC PARNR
0390  8241  AE 49 A6              LDX PARNR
0391  8244  E0 03                 CPX #$03
0392  8246  D0 E3                 BNE PM1
0393  8248  F0 1D                 BEQ M24
0394  824A  20 75 82     M22     JSR ASCNIB
0395  824D  B0 18                 BCS M24
0396  824F  A2 04                 LDX #4
0397  8251  0E 4A A6     M23     ASL P3L
0398  8254  2E 4B A6             ROL P3H
0399  8257  CA                   DEX
0400  8258  D0 F7                 BNE M23
0401  825A  0D 4A A6             ORA P3L
0402  825D  8D 4A A6             STA P3L
0403  8260  A9 FF                 LDA #$FF
0404  8262  8D 33 A6             STA SCR3
0405  8265  D0 C7                 BNE PARFIL
0406  8267  2C 33 A6     M24     BIT SCR3
0407  826A  F0 03                 BEQ M25
0408  826C  EE 49 A6             INC PARNR
0409  826F  C9 0D        M25     CMP #$0D
0410  8271  18                   CLC
0411  8272  4C B8 81             JMP RESXAF
0412  8275  C9 0D        ASCNIB  CMP #$0D        ;C/R?
0413  8277  F0 19                 BEQ M29
0414  8279  C9 30                 CMP #'0
0415  827B  90 0C                 BCC M26
0416  827D  C9 47                 CMP #'G
0417  827F  B0 08                 BCS M26
0418  8281  C9 41                 CMP #'A
0419  8283  B0 08                 BCS M27
0420  8285  C9 3A                 CMP #':
0421  8287  90 06                 BCC M28
0422  8289  C9 30        M26     CMP #'0
0423  828B  38                   SEC             ;CARRY SET --> NON HEX
0424  828C  60                   RTS
0425  828D  E9 37        M27     SBC #$37
0426  828F  29 0F        M28     AND #$0F
0427  8291  18                   CLC
0428  8292  60          M29     RTS
0429  8293  EE 4A A6     INCP3   INC P3L         ;INCREMENT P3 (16 BITS)
0430  8296  D0 03                 BNE *+5
0431  8298  EE 4B A6             INC P3H
0432  829B  60                   RTS
0433  829C  AE 4D A6     P2SCR   LDX P2H         ;MOVE P2 TO FE,FF
0434  829F  86 FF                 STX $FF
0435  82A1  AE 4C A6             LDX P2L
0436  82A4  86 FE                 STX $FE
0437  82A6  60                   RTS
0438  82A7  AE 4B A6     P3SCR   LDX P3H         ;MOVE P3 TO FE,FF
0439  82AA  86 FF                 STX $FF
0440  82AC  AE 4A A6             LDX P3L
0441  82AF  86 FE                 STX $FE
```

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LINE # LOC     CODE        LINE

0442  82B1  60              RTS
0443  82B2  E6 FE     INCCMP INC $FE          ;INCREM FE,FF, COMPARE TO P3
0444  82B4  D0 14            BNE COMPAR
0445  82B6  E6 FF            INC $FF
0446  82B8  D0 10     WRAP   BNE COMPAR       ;TEST FOR WRAP AROUND
0447  82BA  2C BD 82          BIT EXWRAP
0448  82BD  60         EXWRAP RTS
0449  82BE  A5 FE     DECCMP LDA $FE          ;DECREM FE,FF AND COMPARE TO P3
0450  82C0  D0 06            BNE M32
0451  82C2  A5 FF            LDA $FF
0452  82C4  F0 F2            BEQ WRAP
0453  82C6  C6 FF            DEC $FF
0454  82C8  C6 FE     M32    DEC $FE
0455  82CA  20 88 81 COMPAR  JSR SAVER       ;COMPARE FE,FF TO P3
0456  82CD  A5 FF            LDA $FF
0457  82CF  CD 4B A6          CMP P3H
0458  82D2  D0 05            BNE EXITCP
0459  82D4  A5 FE            LDA $FE
0460  82D6  CD 4A A6          CMP P3L
0461  82D9  B8         EXITCP CLV
0462  82DA  4C BE 81          JMP RESXF
0463  82DD  08         CHKSAD PHP             ;16 BIT CKSUM IN SCR6,7
0464  82DE  48               PHA
0465  82DF  18               CLC
0466  82E0  6D 36 A6          ADC SCR6
0467  82E3  8D 36 A6          STA SCR6
0468  82E6  90 03            BCC M33
0469  82E8  EE 37 A6          INC SCR7
0470  82EB  68         M33    PLA
0471  82EC  28               PLP
0472  82ED  60               RTS
0473  82EE  AD 59 A6 OUTPC   LDA PCLR         ;OUTPUT PC
0474  82F1  AE 5A A6          LDX PCHR
0475  82F4  48         OUTXAH PHA
0476  82F5  8A               TXA
0477  82F6  20 FA 82          JSR OUTBYT
0478  82F9  68               PLA
0479  82FA  48         OUTBYT PHA             ;OUTPUT 2 HEX DIGS FROM A
0480  82FB  48               PHA
0481  82FC  4A               LSR A
0482  82FD  4A               LSR A
0483  82FE  4A               LSR A
0484  82FF  4A               LSR A
0485  8300  20 44 8A          JSR NBASOC
0486  8303  68               PLA
0487  8304  20 44 8A          JSR NBASOC
0488  8307  68               PLA
0489  8308  60               RTS
0490  8309  29 0F     NIBASC AND #$0F         ;NIBBLE IN A TO ASCII IN A
0491  830B  C9 0A            CMP #$0A
0492  830D  B0 04            BCS NIBALF
0493  830F  69 30            ADC #$30
0494  8311  90 02            BCC EXITNB
0495  8313  69 36     NIBALF ADC #$36
0496  8315  60         EXITNB RTS
```

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LINE # LOC      CODE        LINE

0497  8316  20 4D 83    CRLFSZ JSR CRLF          ;PRINT CRLF, FF, FE
0498  8319  A6 FF       OUTSZ  LDX $FF
0499  831B  A5 FE              LDA $FE
0500  831D  4C F4 82          JMP OUTXAH
0501  8320  A9 3F       OUTQM  LDA #'?
0502  8322  4C 47 8A          JMP OUTCHR
0503  8325  20 3A 83    OCMCK  JSR COMMA         ;OUT COMMA, CKSUM LO
0504  8328  AD 36 A6          LDA SCR6
0505  832B  4C FA 82          JMP OUTBYT
0506  832E  A9 00       ZERCK  LDA #0            ;INIT CHECKSUM
0507  8330  8D 36 A6          STA SCR6
0508  8333  8D 37 A6          STA SCR7
0509  8336  60                RTS
0510  8337  20 EE 82    OPCCOM JSR OUTPC         ;PC OUT, COMMA OUT
0511  833A  48          COMMA  PHA               ;COMMA OUT
0512  833B  A9 2C              LDA #',
0513  833D  D0 06              BNE SPCP3
0514  833F  20 42 83    SPC2   JSR SPACE         ;2 SPACES OUT
0515  8342  48          SPACE  PHA               ;1 SPACE OUT
0516  8343  A9 20              LDA #$20
0517  8345  20 47 8A    SPCP3  JSR OUTCHR
0518  8348  68                PLA
0519  8349  60                RTS
0520  834A  20 FA 82    OBCRLF JSR OUTBYT        ;BYTE OUT, CRLF OUT
0521  834D  48          CRLF   PHA
0522  834E  A9 0D              LDA #$0D
0523  8350  20 47 8A          JSR OUTCHR
0524  8353  A9 0A              LDA #$0A       ;LINE FEED
0525  8355  20 47 8A          JSR OUTCHR
0526  8358  68                PLA
0527  8359  60                RTS
0528  835A  AE 56 A6    DELAY  LDX TV            ;DELAY DEPENDS ON TV
0529  835D  20 88 81    DL1    JSR SAVER
0530  8360  A9 FF              LDA #$FF
0531  8362  8D 39 A6          STA SCR9
0532  8365  8D 38 A6          STA SCR8
0533  8368  0E 38 A6    DLY1   ASL SCR8
0534  836B  2E 39 A6          ROL SCR9
0535  836E  CA                DEX
0536  836F  D0 F7              BNE DLY1
0537  8371  20 03 89    DLY2   JSR IJSCNV        ;SCAN DISPLAY
0538  8374  20 86 83          JSR INSTAT       ;SEE IF KEY DOWN
0539  8377  B0 0A              BCS DLYO
0540  8379  EE 38 A6          INC SCR8
0541  837C  D0 03              BNE *+5
0542  837E  EE 39 A6          INC SCR9
0543  8381  D0 EE              BNE DLY2
0544  8383  4C BE 81    DLYO   JMP RESXF
0545  8386                ; INSTAT - SEE IF KEY DOWN, RESULT IN CARRY
0546  8386                ; KYSTAT, TSTAT RETURN IMMEDIATELY W/STATUS
0547  8386                ; INSTAT WAITS FOR RELEASE
0548  8386  20 92 83    INSTAT JSR INJISV
0549  8389  90 06              BCC INST2
0550  838B  20 92 83    INST1  JSR INJISV
0551  838E  B0 FB              BCS INST1
```

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LINE # LOC     CODE        LINE

0552  8390  38              SEC
0553  8391  60          INST2  RTS
0554  8392  6C 67 A6    INJISV JMP (INSVEC+1)
0555  8395              ;
0556  8395              ;
0557  8395              ; *** EXECUTE BLOCKS BEGIN HERE
0558  8395              ;
0559  8395              BZPARM=*
0560  8395              ; ZERO PARM COMMANDS
0561  8395              ;
0562  8395  C9 52        REGZ   CMP #'R          ;DISP REGISTERS
0563  8397  D0 5A              BNE GOZ         ;PC,S,F,A,X,Y
0564  8399  20 4D 83    RGBACK JSR CRLF
0565  839C  A9 50              LDA #'P
0566  839E  20 47 8A           JSR OUTCHR
0567  83A1  20 42 83           JSR SPACE
0568  83A4  20 EE 82           JSR OUTPC
0569  83A7  20 D6 81           JSR COMINB
0570  83AA  B0 13              BCS NH3
0571  83AC  8D 34 A6           STA SCR4
0572  83AF  20 D9 81           JSR INBYTE
0573  83B2  B0 0B              BCS NH3
0574  83B4  8D 59 A6           STA PCLR
0575  83B7  AD 34 A6           LDA SCR4
0576  83BA  8D 5A A6           STA PCHR
0577  83BD  90 09              BCC M34
0578  83BF  D0 02        NH3    BNE NOTCR
0579  83C1  18           EXITRG CLC
0580  83C2  60           EXRGP1 RTS
0581  83C3  20 CB 81     NOTCR  JSR ADVCK
0582  83C6  D0 FA              BNE EXRGP1
0583  83C8  A0 00        M34    LDY #0
0584  83CA  C8           M35    INY
0585  83CB  C0 06              CPY #6
0586  83CD  F0 CA              BEQ RGBACK
0587  83CF  20 4D 83           JSR CRLF
0588  83D2  A9 52        NXTRG  LDA #'R
0589  83D4  20 47 8A           JSR OUTCHR
0590  83D7  98                 TYA
0591  83D8  20 44 8A           JSR NBASOC
0592  83DB  20 3F 83           JSR SPC2
0593  83DE  B9 5A A6           LDA PCHR,Y
0594  83E1  20 D3 81           JSR OBCMIN
0595  83E4  B0 05              BCS M36
0596  83E6  99 5A A6           STA PCHR,Y
0597  83E9  90 DF              BCC M35
0598  83EB  F0 D4        M36    BEQ EXITRG
0599  83ED  20 CB 81           JSR ADVCK
0600  83F0  F0 D8              BEQ M35
0601  83F2  60                 RTS
0602  83F3  C9 47        GOZ    CMP #$47
0603  83F5  D0 20              BNE LPZB
0604  83F7  20 4D 83     GO2    JSR CRLF
0605  83FA  20 9C 8B     GO1ENT JSR NACCES       ;WRITE PROT MONITR RAM
0606  83FD  AE 5B A6           LDX SR            ;RESTORE REGS
```

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LINE # LOC      CODE        LINE

0607  8400  9A              TXS
0608  8401  AD 5A A6        LDA PCHR
0609  8404  48              PHA
0610  8405  AD 59 A6        LDA PCLR
0611  8408  48        NR10  PHA
0612  8409  AD 5C A6        LDA FR
0613  840C  48              PHA
0614  840D  AC 5F A6        LDY YR
0615  8410  AE 5E A6        LDX XR
0616  8413  AD 5D A6        LDA AR
0617  8416  40              RTI
0618  8417  C9 11     LPZB  CMP #$11          ;LOAD PAPER TAPE
0619  8419  F0 03           BEQ *+5
0620  841B  4C A7 84        JMP DEPZ
0621  841E  20 88 81        JSR SAVER
0622  8421  20 4D 83        JSR CRLF
0623  8424  A9 00           LDA #0
0624  8426  8D 52 A6        STA ERCNT
0625  8429  20 2E 83  LPZ    JSR ZERCK
0626  842C  20 1B 8A  LP1    JSR INCHR
0627  842F  C9 3B           CMP #$3B
0628  8431  D0 F9           BNE LP1
0629  8433  20 A1 84        JSR LDBYTE
0630  8436  B0 56           BCS TAPERR
0631  8438  D0 09           BNE NUREC
0632  843A  AD 52 A6        LDA ERCNT         ;ERRORS ?
0633  843D  F0 01           BEQ *+3
0634  843F  38        EXITLP SEC
0635  8440  4C BE 81        JMP RESXF
0636  8443  8D 3D A6  NUREC  STA RC
0637  8446  20 A1 84        JSR LDBYTE
0638  8449  B0 43           BCS TAPERR
0639  844B  85 FF           STA $FF
0640  844D  20 A1 84        JSR LDBYTE
0641  8450  B0 D7           BCS LPZ
0642  8452  85 FE           STA $FE
0643  8454  20 A1 84  MORED  JSR LDBYTE
0644  8457  B0 35           BCS TAPERR
0645  8459  A0 00           LDY #0
0646  845B  91 FE           STA ($FE),Y
0647  845D  D1 FE           CMP ($FE),Y
0648  845F  F0 0C           BEQ LPGD
0649  8461  AD 52 A6        LDA ERCNT
0650  8464  29 0F           AND #$0F
0651  8466  C9 0F           CMP #$0F
0652  8468  F0 03           BEQ *+5
0653  846A  EE 52 A6        INC ERCNT
0654  846D  20 B2 82  LPGD   JSR INCCMP
0655  8470  CE 3D A6        DEC RC
0656  8473  D0 DF           BNE MORED
0657  8475  20 D9 81        JSR INBYTE
0658  8478  B0 14           BCS TAPERR
0659  847A  CD 37 A6        CMP SCR7
0660  847D  D0 0C           BNE BADDY
0661  847F  20 D9 81        JSR INBYTE
```

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LINE # LOC     CODE        LINE

0662  8482  B0 0A           BCS TAPERR
0663  8484  CD 36 A6        CMP SCR6
0664  8487  F0 A0           BEQ LPZ
0665  8489  D0 03           BNE TAPERR      ;(ALWAYS)
0666  848B  20 D9 81  BADDY  JSR INBYTE
0667  848E  AD 52 A6  TAPERR LDA ERCNT
0668  8491  29 F0           AND #$F0
0669  8493  C9 F0           CMP #$F0
0670  8495  F0 92           BEQ LPZ
0671  8497  AD 52 A6        LDA ERCNT
0672  849A  69 10           ADC #$10
0673  849C  8D 52 A6        STA ERCNT
0674  849F  D0 88           BNE LPZ
0675  84A1  20 D9 81  LDBYTE JSR INBYTE
0676  84A4  4C DD 82        JMP CHKSAD
0677  84A7  C9 44     DEPZ   CMP #'D         ;DEPOSIT, 0 PARM - USE (OLD)
0678  84A9  D0 03           BNE MEMZ
0679  84AB  4C E1 84        JMP NEWLN
0680  84AE  C9 4D     MEMZ   CMP #'M         ;MEM, 0 PARM   USE (OLD)
0681  84B0  D0 03           BNE VERZ
0682  84B2  4C 17 85        JMP NEWLOC
0683  84B5  C9 56     VERZ   CMP #'V         ;VERIFY, 0 PARM - USE (OLD)
0684  84B7  D0 0D           BNE L1ZB        ; ... DO 8 BYTES (LIKE VER 1 PARM
0685  84B9  A5 FE           LDA $FE
0686  84BB  8D 4A A6        STA P3L
0687  84BE  A5 FF           LDA $FF
0688  84C0  8D 4B A6        STA P3H
0689  84C3  4C 9A 85        JMP VER1+4
0690  84C6  C9 12     L1ZB   CMP #$12        ;LOAD KIM, ZERO PARM
0691  84C8  D0 05           BNE L2ZB
0692  84CA  A0 00           LDY #0          ;MODE = KIM
0693  84CC  4C 78 8C  L1J    JMP LENTRY      ;GO TO CASSETTE ROUTINE
0694  84CF  C9 13     L2ZB   CMP #$13        ;LOAD HS, ZERO PARM
0695  84D1  D0 04           BNE EZPARM
0696  84D3  A0 80           LDY #$80        ;MODE = HS
0697  84D5  D0 F5           BNE L1J         ;(ALWAYS)
0698  84D7  6C 6D A6  EZPARM JMP (URCVEC+1) ; ... ELSE UNREC CMD
0699  84DA              B1PARM=*
0700  84DA              ;
0701  84DA              ; 1 PARAMETER COMMAND EXEC BLOCKS
0702  84DA              ;
0703  84DA  C9 44     DEP1   CMP #'D         ;DEPOSIT, 1 PARM
0704  84DC  D0 32           BNE MEM1
0705  84DE  20 A7 82        JSR P3SCR
0706  84E1  20 16 83  NEWLN  JSR CRLFSZ
0707  84E4  A0 00           LDY #0
0708  84E6  A2 08           LDX #$8
0709  84E8  20 42 83  DEPBYT JSR SPACE
0710  84EB  20 D9 81        JSR INBYTE
0711  84EE  B0 11           BCS NH41
0712  84F0  91 FE           STA ($FE),Y
0713  84F2  D1 FE           CMP ($FE),Y     ;VERIFY
0714  84F4  F0 03           BEQ DEPN
0715  84F6  20 20 83        JSR OUTQM       ;TYPE ? IF NG
0716  84F9  20 B2 82  DEPN   JSR INCCMP
```

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LINE # LOC      CODE        LINE

0717  84FC  CA              DEX
0718  84FD  D0 E9           BNE DEPBYT
0719  84FF  F0 E0           BEQ NEWLN
0720  8501  F0 0B     NH41  BEQ DEPEC
0721  8503  C9 20           CMP #$20          ;SPACE = FWD
0722  8505  D0 4C           BNE DEPES
0723  8507  70 F0           BVS DEPN
0724  8509  20 42 83        JSR SPACE
0725  850C  10 EB           BPL DEPN
0726  850E  18       DEPEC  CLC
0727  850F  60              RTS
0728  8510  C9 4D     MEM1  CMP #'M           ;MEMORY, 1 PARM
0729  8512  D0 65           BNE G01
0730  8514  20 A7 82        JSR P3SCR
0731  8517  20 16 83  NEWLOC JSR CRLFSZ
0732  851A  20 3A 83        JSR COMMA
0733  851D  A0 00           LDY #0
0734  851F  B1 FE           LDA ($FE),Y
0735  8521  20 D3 81        JSR OBCMIN
0736  8524  B0 11           BCS NH42
0737  8526  A0 00           LDY #0
0738  8528  91 FE           STA ($FE),Y
0739  852A  D1 FE           CMP ($FE),Y       ;VERIFY MEM
0740  852C  F0 03           BEQ NXTLOC
0741  852E  20 20 83        JSR OUTQM         ;TYPE ? AND CONTINUE
0742  8531  20 B2 82  NXTLOC JSR INCCMP
0743  8534  18              CLC
0744  8535  90 E0           BCC NEWLOC
0745  8537  F0 3E     NH42  BEQ EXITM1
0746  8539  50 04           BVC *+6
0747  853B  C9 3C           CMP #'<
0748  853D  F0 D8           BEQ NEWLOC
0749  853F  C9 20           CMP #$20        ;SPACE ?
0750  8541  F0 EE           BEQ NXTLOC
0751  8543  C9 3E           CMP #'>
0752  8545  F0 EA           BEQ NXTLOC
0753  8547  C9 2B           CMP #'+
0754  8549  F0 10           BEQ LOCP8
0755  854B  C9 3C           CMP #'<
0756  854D  F0 06           BEQ PRVLOC
0757  854F  C9 2D           CMP #'-
0758  8551  F0 16           BEQ LOCM8
0759  8553  38       DEPES  SEC
0760  8554  60              RTS
0761  8555  20 BE 82  PRVLOC JSR DECCMP       ;BACK ONE BYT
0762  8558  18              CLC
0763  8559  90 BC           BCC NEWLOC
0764  855B  A5 FE     LOCP8 LDA $FE           ;GO FWD 8 BYTES
0765  855D  18              CLC
0766  855E  69 08           ADC #$08
0767  8560  85 FE           STA $FE
0768  8562  90 02           BCC M42
0769  8564  E6 FF           INC $FF
0770  8566  18       M42    CLC
0771  8567  90 AE           BCC NEWLOC
```

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LINE # LOC      CODE        LINE

0772  8569  A5 FE        LOCM8  LDA $FE          ; GO BACKWD 8 BYTE
0773  856B  38                 SEC
0774  856C  E9 08              SBC #$08
0775  856E  85 FE              STA $FE
0776  8570  B0 02              BCS M43
0777  8572  C6 FF              DEC $FF
0778  8574  18           M43    CLC
0779  8575  90 A0              BCC NEWLOC
0780  8577  18           EXITM1 CLC
0781  8578  60                 RTS
0782  8579  C9 47        G01    CMP #'G          ; GO, 1 PARM (RTRN ADDR ON STK)
0783  857B  D0 19              BNE VER1         ...  PARM IS ADDR TO GO TO
0784  857D  20 4D 83           JSR CRLF
0785  8580  20 9C 8B           JSR NACCES       ;WRITE PROT MONITR RAM
0786  8583  A2 FF              LDX #$FF         ;PUSH RETURN ADDR
0787  8585  9A                 TXS
0788  8586  A9 7F              LDA #$7F
0789  8588  48                 PHA
0790  8589  A9 FF              LDA #$FF
0791  858B  48                 PHA
0792  858C  AD 4B A6           LDA P3H
0793  858F  48                 PHA
0794  8590  AD 4A A6           LDA P3L
0795  8593  4C 08 84           JMP NR10
0796  8596  C9 56        VER1   CMP #'V          ;VERIFY, 1 PARM (8 BYTES, CKSUM)
0797  8598  D0 1A              BNE JUMP1
0798  859A  AD 4A A6           LDA P3L
0799  859D  8D 4C A6           STA P2L
0800  85A0  18                 CLC
0801  85A1  69 07              ADC #$07
0802  85A3  8D 4A A6           STA P3L
0803  85A6  AD 4B A6           LDA P3H
0804  85A9  8D 4D A6           STA P2H
0805  85AC  69 00              ADC #0
0806  85AE  8D 4B A6           STA P3H
0807  85B1  4C 40 86           JMP VER2+4
0808  85B4  C9 4A        JUMP1  CMP #'J          ;JUMP (JUMP TABLE IN SYS RAM)
0809  85B6  D0 1F              BNE L11B
0810  85B8  AD 4A A6           LDA P3L
0811  85BB  C9 08              CMP #$8          ; 0-7 ONLY VALID
0812  85BD  B0 26              BCS JUM2
0813  85BF  20 9C 8B           JSR NACCES       ;WRITE PROT SYS RAM
0814  85C2  0A                 ASL A
0815  85C3  A8                 TAY
0816  85C4  A2 FF              LDX #$FF         ;INIT STK PTR
0817  85C6  9A                 TXS
0818  85C7  A9 7F              LDA #$7F         ;PUSH COLD RETURN
0819  85C9  48                 PHA
0820  85CA  A9 FF              LDA #$FF
0821  85CC  48                 PHA
0822  85CD  B9 21 A6           LDA JTABLE+1,Y   ;GET ADDR FROM TABLE
0823  85D0  48                 PHA              ;PUSH ON STACK
0824  85D1  B9 20 A6           LDA JTABLE,Y
0825  85D4  4C 08 84           JMP NR10         ;LOAD UP USER REG'S AND RTI
0826  85D7  C9 12        L11B   CMP #$12         ;LOAD KIM FMT, 1 PARM
```

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LINE # LOC      CODE        LINE

0827  85D9  D0 14           BNE L21B
0828  85DB  A0 00           LDY #0            ;MODE   KIM
0829  85DD  AD 4A A6  L11C  LDA P3L
0830  85E0  C9 FF           CMP #$FF          ; ID MUST NOT BE FF
0831  85E2  D0 02           BNE *+4
0832  85E4  38              SEC
0833  85E5  60        JUMP  RTS
0834  85E6  20 08 82        JSR PSHOVE        ;FIX PARM POSITION
0835  85E9  20 08 82  L11D  JSR PSHOVE
0836  85EC  4C 78 8C        JMP LENTRY
0837  85EF  C9 13     L21B  CMP #$13          ;LOAD TAPE, HS FMT, 1 PARM
0838  85F1  D0 04           BNE WPR1B
0839  85F3  A0 80           LDY #$80          ;MODE = HS
0840  85F5  D0 E6           BNE L11C
0841  85F7  C9 57     WPR1B CMP #'W           ;WRITE PROT USER RAM
0842  85F9  D0 1B           BNE E1PARM
0843  85FB  AD 4A A6        LDA P3L           ; FIRST DIG IS 1K ABOVE 0,
0844  85FE  29 11           AND #$11          ; SECOND IS 2K ABOVE 0
0845  8600  C9 08           CMP #8            ; THIRD IS 3K ABOVE 0.
0846  8602  2A              ROL A
0847  8603  4E 4B A6        LSR P3H
0848  8606  2A              ROL A
0849  8607  0A              ASL A
0850  8608  29 0F           AND #$0F
0851  860A  49 0F           EOR #$0F          ;0 IS PROTECT
0852  860C  8D 01 AC        STA DR3A
0853  860F  A9 0F           LDA #$0F
0854  8611  8D 03 AC        STA DDR3A
0855  8614  18              CLC
0856  8615  60              RTS
0857  8616  4C 27 88  E1PARM JMP CALC3
0858  8619              B2PARM=*
0859  8619              ;
0860  8619              ; 2 PARAMETER EXEC BLOCKS
0861  8619              ;
0862  8619  C9 10     STD2  CMP #$10          ;STORE DOUBLE BYTE
0863  861B  D0 12           BNE MEM2
0864  861D  20 A7 82        JSR P3SCR
0865  8620  AD 4D A6        LDA P2H
0866  8623  A0 01           LDY #1
0867  8625  91 FE           STA ($FE),Y
0868  8627  88              DEY
0869  8628  AD 4C A6        LDA P2L
0870  862B  91 FE           STA ($FE),Y
0871  862D  18              CLC
0872  862E  60              RTS
0873  862F  C9 4D     MEM2  CMP #'M           ;CONTINUE MEM SEARCH W/OLD PTR
0874  8631  D0 09           BNE VER2
0875  8633  AD 4C A6        LDA P2L
0876  8636  8D 4E A6        STA P1L
0877  8639  4C 08 88        JMP MEM3C
0878  863C  C9 56     VER2  CMP #'V           ;VERIFY MEM W/CHKSUMS , 2 PARM
0879  863E  D0 48           BNE L12B
0880  8640  20 9C 82        JSR P2SCR
0881  8643  20 2E 83        JSR ZERCK
```

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LINE # LOC      CODE        LINE

0882  8646  20 16 83    VADDR  JSR CRLFSZ
0883  8649  A2 08               LDX #8
0884  864B  20 42 83    V2     JSR SPACE
0885  864E  A0 00               LDY #0
0886  8650  B1 FE               LDA ($FE),Y
0887  8652  20 DD 82            JSR CHKSAD
0888  8655  20 FA 82            JSR OUTBYT
0889  8658  20 B2 82            JSR INCCMP
0890  865B  70 10               BVS V1
0891  865D  F0 02               BEQ *+4
0892  865F  B0 0C               BCS V1
0893  8661  CA                  DEX
0894  8662  D0 E7               BNE V2
0895  8664  20 25 83    VOCK   JSR OCMCK
0896  8667  20 86 83            JSR INSTAT
0897  866A  90 DA               BCC VADDR
0898  866C  60                  RTS
0899  866D  20 BE 82    V1     JSR DECCMP
0900  8670  E0 08               CPX #8
0901  8672  F0 03               BEQ *+5
0902  8674  E8                  INX
0903  8675  10 F6               BPL V1
0904  8677  20 25 83            JSR OCMCK
0905  867A  20 4D 83            JSR CRLF
0906  867D  20 42 83            JSR SPACE
0907  8680  AE 37 A6            LDX SCR7
0908  8683  20 F4 82            JSR OUTXAH
0909  8686  18                  CLC
0910  8687  60                  RTS
0911  8688  C9 12       L12B   CMP #$12          ;LOAD KIM FMT TAPE, 2 PARMS
0912  868A  D0 0C               BNE SP2B
0913  868C  AD 4C A6    L12C   LDA P2L
0914  868F  C9 FF               CMP #$FF          ;ID MUST BE FF
0915  8691  D0 F4               BNE L12B-1        ;ERR
0916  8693  A0 00               LDY #0            ;MODE = HS
0917  8695  4C E9 85            JMP L11D
0918  8698  C9 1C       SP2B   CMP #$1C          ;SAVE PAPER TAPE, 2 PARMS
0919  869A  D0 75               BNE E2PARM
0920  869C  18                  CLC
0921  869D  20 88 81            JSR SAVER
0922  86A0  20 9C 82            JSR P2SCR
0923  86A3  20 FA 86    SP2C   JSR DIFFZ
0924  86A6  B0 03               BCS SP2D
0925  86A8  4C C4 81    SPEXIT JMP RESALL
0926  86AB  20 4D 83    SP2D   JSR CRLF
0927  86AE  CD 58 A6            CMP MAXRC
0928  86B1  90 05               BCC SP2E
0929  86B3  AD 58 A6            LDA MAXRC
0930  86B6  B0 02               BCS SP2F
0931  86B8  69 01       SP2E   ADC #1
0932  86BA  8D 3D A6    SP2F   STA RC
0933  86BD  A9 3B               LDA #$3B
0934  86BF  20 47 8A            JSR OUTCHR
0935  86C2  AD 3D A6            LDA RC
0936  86C5  20 F4 86            JSR SVBYTE
```

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LINE # LOC      CODE        LINE

0937  86C8  A5 FF           LDA $FF
0938  86CA  20 F4 86        JSR SVBYTE
0939  86CD  A5 FE           LDA $FE
0940  86CF  20 F4 86        JSR SVBYTE
0941  86D2  A0 00     MORED2 LDY #$00
0942  86D4  B1 FE           LDA ($FE),Y
0943  86D6  20 F4 86        JSR SVBYTE
0944  86D9  20 86 83        JSR INSTAT      ;STOP IF KEY DEPRESSED
0945  86DC  B0 CA           BCS SPEXIT
0946  86DE  20 B2 82        JSR INCCMP
0947  86E1  70 C5           BVS SPEXIT
0948  86E3  CE 3D A6        DEC RC
0949  86E6  D0 EA           BNE MORED2
0950  86E8  AE 37 A6        LDX SCR7
0951  86EB  AD 36 A6        LDA SCR6
0952  86EE  20 F4 82        JSR OUTXAH
0953  86F1  18              CLC
0954  86F2  90 AF           BCC SP2C
0955  86F4  20 DD 82  SVBYTE JSR CHKSAD
0956  86F7  4C FA 82        JMP OUTBYT
0957  86FA  20 2E 83  DIFFZ  JSR ZERCK
0958  86FD  AD 4A A6  DIFFL  LDA P3L
0959  8700  38              SEC
0960  8701  E5 FE           SBC $FE
0961  8703  48              PHA
0962  8704  AD 4B A6        LDA P3H
0963  8707  E5 FF           SBC $FF
0964  8709  F0 04           BEQ DIFF1
0965  870B  68              PLA
0966  870C  A9 FF           LDA #$FF
0967  870E  60              RTS
0968  870F  68        DIFF1  PLA
0969  8710  60        DIFFL2 RTS
0970  8711  4C 27 88  E2PARM JMP CALC3       ;MAY BE CALC OR EXEC
0971  8714              B3PARM=*
0972  8714              ;
0973  8714              ; 3 PARAMETER COMMAND EXECUTE BLOCKS
0974  8714              ;
0975  8714  C9 46       FILL3  CMP #'F        ;FILL MEM
0976  8716  D0 21              BNE BLK3
0977  8718  20 9C 82           JSR P2SCR
0978  871B  A9 00              LDA #0
0979  871D  8D 52 A6           STA ERCNT       ;ZERO ERROR COUNT
0980  8720  AD 4E A6           LDA P1L
0981  8723  A0 00        F1     LDY #0
0982  8725  91 FE              STA ($FE),Y
0983  8727  D1 FE              CMP ($FE),Y     ;VERIFY
0984  8729  F0 03              BEQ F3
0985  872B  20 C1 87           JSR BRTT        ;INC ERCNT (UP TO FF)
0986  872E  20 B2 82     F3    JSR INCCMP
0987  8731  70 7C              BVS B1
0988  8733  F0 EE              BEQ F1
0989  8735  90 EC              BCC F1
0990  8737  B0 76        F2    BCS B1          ;(ALWAYS)
0991  8739  C9 42        BLK3  CMP #'B         ;BLOCK MOVE (OVERLAP OK)
```

```
LINE # LOC      CODE        LINE

0992  873B  F0 03           BEQ *+5
0993  873D  4C CD 87        JMP S13B
0994  8740  A9 00           LDA #0
0995  8742  8D 52 A6        STA ERCNT
0996  8745  20 9C 82        JSR P2SCR
0997  8748  AD 4E A6        LDA P1L
0998  874B  85 FC           STA $FC
0999  874D  AD 4F A6        LDA P1H
1000  8750  85 FD           STA $FD
1001  8752  C5 FF           CMP $FF          ;WHICH DIRECTION TO MOVE?
1002  8754  D0 06           BNE *+8
1003  8756  A5 FC           LDA $FC
1004  8758  C5 FE           CMP $FE
1005  875A  F0 53           BEQ B1           ;16 BITS EQUAL THEN FINISHED
1006  875C  B0 14           BCS B2           ;MOVE DEC'NG
1007  875E  20 B7 87  BLP    JSR BMOVE        ;MOVE INC'NG
1008  8761  E6 FC           INC $FC
1009  8763  D0 02           BNE *+4
1010  8765  E6 FD           INC $FD
1011  8767  20 B2 82        JSR INCCMP
1012  876A  70 43           BVS B1
1013  876C  F0 F0           BEQ BLP
1014  876E  90 EE           BCC BLP
1015  8770  B0 3D           BCS B1
1016  8772  A5 FC     B2    LDA $FC          ;CALC VALS FOR MOVE DEC'NG
1017  8774  18              CLC
1018  8775  6D 4A A6        ADC P3L
1019  8778  85 FC           STA $FC
1020  877A  A5 FD           LDA $FD
1021  877C  6D 4B A6        ADC P3H
1022  877F  85 FD           STA $FD
1023  8781  38              SEC
1024  8782  A5 FC           LDA $FC
1025  8784  E5 FE           SBC $FE
1026  8786  85 FC           STA $FC
1027  8788  A5 FD           LDA $FD
1028  878A  E5 FF           SBC $FF
1029  878C  85 FD           STA $FD
1030  878E  20 A7 82        JSR P3SCR
1031  8791  AD 4C A6        LDA P2L
1032  8794  8D 4A A6        STA P3L
1033  8797  AD 4D A6        LDA P2H
1034  879A  8D 4B A6        STA P3H
1035  879D  20 B7 87  BLP1   JSR BMOVE        ;MOVE DEC'NG
1036  87A0  A5 FC           LDA $FC
1037  87A2  D0 02           BNE *+4
1038  87A4  C6 FD           DEC $FD
1039  87A6  C6 FC           DEC $FC
1040  87A8  20 BE 82        JSR DECCMP
1041  87AB  70 02           BVS B1
1042  87AD  B0 EE           BCS BLP1
1043  87AF  AD 52 A6  B1    LDA ERCNT        ;FINISHED, TEST ERCNT
1044  87B2  38              SEC
1045  87B3  D0 01           BNE *+3
1046  87B5  18              CLC
```

```
LINE # LOC      CODE        LINE

1047  87B6  60              RTS
1048  87B7  A0 00     BMOVE  LDY #0          ;MOVE 1 BYT + VER
1049  87B9  B1 FE           LDA ($FE),Y
1050  87BB  91 FC           STA ($FC),Y
1051  87BD  D1 FC           CMP ($FC),Y
1052  87BF  F0 0B           BEQ BRT
1053  87C1  AC 52 A6  BRTT   LDY ERCNT       ;INC ERCNT, DONT PASS FF
1054  87C4  C0 FF           CPY #$FF
1055  87C6  F0 04           BEQ *+6
1056  87C8  C8              INY
1057  87C9  8C 52 A6        STY ERCNT
1058  87CC  60        BRT    RTS
1059  87CD  C9 1D     S13B   CMP #$1D         ;SAVE KIM FMT TAPE, 3 PARMS
1060  87CF  D0 15           BNE S23B
1061  87D1  A0 00           LDY #$0           ;MODE   KIM
1062  87D3  AD 4E A6  S13C   LDA P1L
1063  87D6  D0 02           BNE *+4           ;ID MUST NOT   0
1064  87D8  38              SEC
1065  87D9  60              RTS
1066  87DA  C9 FF           CMP #$FF          ;ID MUST NOT = FF
1067  87DC  D0 02           BNE *+4
1068  87DE  38        S1NG   SEC
1069  87DF  60              RTS
1070  87E0  20 93 82        JSR INCP3         ;USE END ADDR + 1
1071  87E3  4C 87 8E        JMP SENTRY
1072  87E6  C9 1E     S23B   CMP #$1E         ;SAVE HS FMT TAPE, 3 PARMS
1073  87E8  D0 04           BNE L23P
1074  87EA  A0 80           LDY #$80          ;MODE = HS
1075  87EC  D0 E5           BNE S13C          ;(ALWAYS)
1076  87EE  C9 13     L23P   CMP #$13         ;LOAD HS, 3 PARMS
1077  87F0  D0 0F           BNE MEM3
1078  87F2  AD 4E A6        LDA P1L
1079  87F5  C9 FF           CMP #$FF          ;ID MUST BE FF
1080  87F7  D0 E5           BNE S1NG          ;ERR RETURN
1081  87F9  20 93 82        JSR INCP3         ;USE END ADDR + 1
1082  87FC  A0 80           LDY #$80          ;MODE = HS
1083  87FE  4C 78 8C        JMP LENTRY
1084  8801  C9 4D     MEM3   CMP #'M          ;MEM 3 SEARCH   BYTE
1085  8803  D0 22           BNE CALC3
1086  8805  20 9C 82        JSR P2SCR
1087  8808  AD 4E A6  MEM3C  LDA P1L
1088  880B  A0 00           LDY #0
1089  880D  D1 FE           CMP ($FE),Y
1090  880F  F0 0B           BEQ MEM3E         ;FOUND SEARCH BYTE?
1091  8811  20 B2 82  MEM3D  JSR INCCMP       ;NO, INC BUFFER ADDR
1092  8814  70 04           BVS MEM3EX        ;WRAP AROUND?
1093  8816  F0 F0           BEQ MEM3C
1094  8818  90 EE           BCC MEM3C
1095  881A  18        MEM3EX CLC
1096  881B  60              RTS               ;SEARCHED TO BOUND
1097  881C  20 17 85  MEM3E  JSR NEWLOC       ;FOUND SEARCH BYTE
1098  881F  90 05           BCC MEM3F
1099  8821  C9 47           CMP #'G           ;ENTERED G?
1100  8823  F0 EC           BEQ MEM3D
1101  8825  38              SEC
```

```
LINE # LOC     CODE        LINE

1102  8826  60            MEM3F  RTS
1103  8827  C9 43         CALC3  CMP #'C CLACULATE, 1, 2 OR 3 PARMS
1104  8829  D0 26                BNE EXE3          ;RESULT = P1+P2-P3
1105  882B  20 4D 83      C1     JSR CRLF
1106  882E  20 42 83              JSR SPACE
1107  8831  18                    CLC
1108  8832  AD 4E A6              LDA P1L
1109  8835  6D 4C A6              ADC P2L
1110  8838  A8                    TAY
1111  8839  AD 4F A6              LDA P1H
1112  883C  6D 4D A6              ADC P2H
1113  883F  AA                    TAX
1114  8840  38                    SEC
1115  8841  98                    TYA
1116  8842  ED 4A A6              SBC P3L
1117  8845  A8                    TAY
1118  8846  8A                    TXA
1119  8847  ED 4B A6              SBC P3H
1120  884A  AA                    TAX
1121  884B  98                    TYA
1122  884C  20 F4 82              JSR OUTXAH
1123  884F  18                    CLC
1124  8850  60                    RTS
1125  8851  C9 45         EXE3   CMP #'E           ;EXECUTE FROM RAM, 1-3 PARMS
1126  8853  D0 57                BNE E3PARM
1127  8855               ; SEE IF VECTOR ALREADY MOVED
1128  8855  AD 62 A6              LDA INVEC+2       ;INVEC MOVED TO SCRA, SCRB
1129  8858               ; HI BYTE OF EXEVEC MUST BE DIFFERENT FROM INVEC
1130  8858  CD 73 A6              CMP EXEVEC+1      ;$FA, $FB USED AS RAM PTR
1131  885B  F0 15                 BEQ PTRIN
1132  885D  8D 3B A6              STA SCRA+1        ;SAVE INVEC IN SCRA,B
1133  8860  AD 61 A6              LDA INVEC+1
1134  8863  8D 3A A6              STA SCRA
1135  8866  AD 72 A6              LDA EXEVEC        ;PUT ADDR OF RIN IN INVEC
1136  8869  8D 61 A6              STA INVEC+1
1137  886C  AD 73 A6              LDA EXEVEC+1
1138  886F  8D 62 A6              STA INVEC+2
1139  8872  AD 4B A6      PTRIN  LDA P3H           ;INIT RAM PTR IN $FA, $FB
1140  8875  85 FB                 STA $FB
1141  8877  AD 4A A6              LDA P3L
1142  887A  85 FA                 STA $FA
1143  887C  18                    CLC
1144  887D  60                    RTS
1145  887E  20 88 81      RIN    JSR SAVER         ;GET INPUT FROM RAM
1146  8881  A0 00                 LDY #$0           ;RAM PTR IN $FA, $FB
1147  8883  B1 FA                 LDA ($FA),Y
1148  8885  F0 12                 BEQ RESTIV        ;IF 00 BYTE, RESTORE INVEC
1149  8887  E6 FA                 INC $FA
1150  8889  D0 02                 BNE *+4
1151  888B  E6 FB                 INC $FB
1152  888D  2C 53 A6              BIT TECHO         ;ECHO CHARS IN ?
1153  8890  10 03                 BPL *+5
1154  8892  20 47 8A              JSR OUTCHR
1155  8895  18                    CLC
1156  8896  4C B8 81              JMP RESXAF
```

```
LINE # LOC     CODE        LINE

1157  8899  AD 3A A6    RESTIV LDA SCRA         ;RESTORE INVEC
1158  889C  8D 61 A6           STA INVEC+1
1159  889F  AD 3B A6           LDA SCRA+1
1160  88A2  8D 62 A6           STA INVEC+2
1161  88A5  18                 CLC
1162  88A6  20 1B 8A           JSR INCHR
1163  88A9  4C B8 81           JMP RESXAF
1164  88AC  6C 6D A6    E3PARM JMP (URCVEC+1)  ;... ELSE UNREC CMD
1165  88AF               ; ***
1166  88AF               ; *** HEX KEYBOARD I/O
1167  88AF               ; ***
1168  88AF  20 88 81    GETKEY JSR SAVER        ;FIND KEY
1169  88B2  20 CF 88           JSR GK
1170  88B5  C9 FE              CMP #$FE
1171  88B7  D0 13              BNE EXITGK
1172  88B9  20 CF 88           JSR GK
1173  88BC  8A                 TXA
1174  88BD  0A                 ASL A
1175  88BE  0A                 ASL A
1176  88BF  0A                 ASL A
1177  88C0  0A                 ASL A
1178  88C1  8D 3E A6           STA SCRE
1179  88C4  20 CF 88           JSR GK
1180  88C7  8A                 TXA
1181  88C8  18                 CLC
1182  88C9  6D 3E A6           ADC SCRE
1183  88CC  4C B8 81    EXITGK JMP RESXAF
1184  88CF  A9 00       GK     LDA #0
1185  88D1  8D 55 A6           STA KSHFL
1186  88D4  20 03 89    GK1    JSR IJSCNV      ;SCAN KB
1187  88D7  F0 FB              BEQ GK1
1188  88D9  20 2C 89           JSR LRNKEY      ;WHAT KEY IS IT?
1189  88DC  F0 F6              BEQ GK1
1190  88DE  48                 PHA
1191  88DF  8A                 TXA
1192  88E0  48                 PHA
1193  88E1  20 72 89           JSR BEEP
1194  88E4  20 23 89    GK2    JSR KEYQ
1195  88E7  D0 FB              BNE GK2         ;Z=0 IF KEY DOWN
1196  88E9  20 9B 89           JSR NOBEEP      ;DELAY (DEBOUNCE) W/O BEEP
1197  88EC  20 23 89           JSR KEYQ
1198  88EF  D0 F3              BNE GK2
1199  88F1  68                 PLA
1200  88F2  AA                 TAX
1201  88F3  68                 PLA
1202  88F4  C9 FF              CMP #$FF        ;IF SHIFT, SET FLAG + GET NEXT KEY
1203  88F6  D0 07              BNE EXITG
1204  88F8  A9 19              LDA #$19
1205  88FA  8D 55 A6           STA KSHFL
1206  88FD  D0 D5              BNE GK1
1207  88FF  60          EXITG  RTS
1208  8900  20 C1 89    HDOUT  JSR OUTDSP      ;CHAR OUT, SCAN KB
1209  8903  6C 70 A6    IJSCNV JMP (SCNVEC+1)
1210  8906  A9 09       SCAND  LDA #$9          ;SCAN DISPLAY FROM DISBUF
1211  8908  20 A5 89           JSR CONFIG
```

```
LINE # LOC      CODE        LINE

1212  890B  A2 05           LDX #5
1213  890D  A0 00     SC1   LDY #0
1214  890F  BD 40 A6        LDA DISBUF,X
1215  8912  8C 00 A4        STY PADA
1216  8915  8E 02 A4        STX PBDA
1217  8918  8D 00 A4        STA PADA
1218  891B  A0 10           LDY #$10
1219  891D  88        SC2   DEY
1220  891E  D0 FD           BNE SC2
1221  8920  CA              DEX
1222  8921  10 EA           BPL SC1
1223  8923  20 A3 89  KEYQ  JSR KSCONF      ; KEY DOWN ? (YES THEN Z=0)
1224  8926  AD 00 A4        LDA PADA
1225  8929  49 7F           EOR #$7F
1226  892B  60              RTS
1227  892C  29 3F     LRNKEY AND #$3F       ;DETERMINE WHAT KEY IS DOWN
1228  892E  8D 3F A6        STA SCRF
1229  8931  A9 05           LDA #$05
1230  8933  20 A5 89        JSR CONFIG
1231  8936  AD 02 A4        LDA PBDA
1232  8939  29 07           AND #$07
1233  893B  49 07           EOR #$07
1234  893D  D0 05           BNE LK1
1235  893F  2C 00 A4        BIT PADA
1236  8942  30 1A           BMI NOKEY
1237  8944  C9 04     LK1   CMP #$04
1238  8946  90 02           BCC LK2
1239  8948  A9 03           LDA #$03
1240  894A  0A        LK2   ASL A
1241  894B  0A              ASL A
1242  894C  0A              ASL A
1243  894D  0A              ASL A
1244  894E  0A              ASL A
1245  894F  0A              ASL A
1246  8950  18              CLC
1247  8951  6D 3F A6        ADC SCRF
1248  8954  A2 19           LDX #$19
1249  8956  DD D6 8B  LK3   CMP SYM,X
1250  8959  F0 05           BEQ FOUND
1251  895B  CA              DEX
1252  895C  10 F8           BPL LK3
1253  895E  E8        NOKEY INX
1254  895F  60              RTS
1255  8960  8A        FOUND TXA
1256  8961  18              CLC
1257  8962  6D 55 A6        ADC KSHFL
1258  8965  AA              TAX
1259  8966  BD EF 8B        LDA ASCII,X
1260  8969  60              RTS
1261  896A  20 23 89  KYSTAT JSR KEYQ       ;KEY DOWN? RETURN IN CARRY
1262  896D  18              CLC
1263  896E  F0 01           BEQ *+3
1264  8970  38              SEC
1265  8971  60              RTS
1266  8972  20 88 81  BEEP  JSR SAVER       ;DELAY (BOUNCE) W/BEEP
```

```
LINE # LOC      CODE        LINE

1267  8975  A9 0D        BEEPP3 LDA #$0D
1268  8977  20 A5 89     BEEPP5 JSR CONFIG
1269  897A  A2 40               LDX #$40       ;DURATION CONSTANT
1270  897C  A9 08        BE1    LDA #8
1271  897E  8D 02 A4            STA PBDA
1272  8981  20 95 89            JSR BE2
1273  8984  A9 06               LDA #6
1274  8986  8D 02 A4            STA PBDA
1275  8989  20 95 89            JSR BE2
1276  898C  CA                  DEX
1277  898D  D0 ED               BNE BE1
1278  898F  20 A3 89            JSR KSCONF
1279  8992  4C C4 81            JMP RESALL
1280  8995  A0 28        BE2    LDY #$28
1281  8997  88          BE3    DEY
1282  8998  D0 FD               BNE BE3
1283  899A  60                  RTS
1284  899B  20 88 81     NOBEEP JSR SAVER        ;DELAY W/O BEEP
1285  899E  A9 01               LDA #$01
1286  89A0  4C 77 89            JMP BEEPP5
1287  89A3  A9 01        KSCONF LDA #$1          ;CONFIGURE FOR KEYBOARD
1288  89A5  20 88 81     CONFIG JSR SAVER        ;CONFIGURE I/O FROM TABLE VAL
1289  89A8  A0 01               LDY #$01
1290  89AA  AA                  TAX
1291  89AB  BD C8 8B     CON1   LDA VALSP2,X
1292  89AE  99 02 A4            STA PBDA,Y
1293  89B1  BD C6 8B            LDA VALS,X
1294  89B4  99 00 A4            STA PADA,Y
1295  89B7  CA                  DEX
1296  89B8  88                  DEY
1297  89B9  10 F0               BPL CON1
1298  89BB  4C C4 81            JMP RESALL
1299  89BE  20 AF 88     HKEY   JSR GETKEY       ;GET KEY FROM KB AND ECHO ON KB
1300  89C1  20 88 81     OUTDSP JSR SAVER        ;DISPLAY OUT
1301  89C4  29 7F               AND #$7F
1302  89C6  C9 07               CMP #$07
1303  89C8  D0 03               BNE NBELL
1304  89CA  4C 75 89            JMP BEEPP3
1305  89CD  20 06 8A     NBELL  JSR TEXT         ;PUSH INTO SCOPE BUFFER
1306  89D0  C9 2C               CMP #$2C       ;SINGLE QUOTE?
1307  89D2  D0 0A               BNE OUD1
1308  89D4  AD 45 A6            LDA RDIG
1309  89D7  09 80               ORA #$80
1310  89D9  8D 45 A6            STA RDIG
1311  89DC  D0 25               BNE EXITOD
1312  89DE  A2 3A        OUD1   LDX #$3A
1313  89E0  DD EE 8B     OUD2   CMP ASCIM1,X
1314  89E3  F0 05               BEQ GETSGS
1315  89E5  CA                  DEX
1316  89E6  D0 F8               BNE OUD2
1317  89E8  F0 19               BEQ EXITOD
1318  89EA  BD 28 8C     GETSGS LDA SEGSM1,X    ;GET CORR SEG CODE FROM TABLE
1319  89ED  C9 F0               CMP #$F0
1320  89EF  F0 12               BEQ EXITOD
1321  89F1  A2 00               LDX #0
```

```
LINE # LOC      CODE        LINE

1322  89F3  48              PHA
1323  89F4  BD 41 A6  OUD3  LDA DISBUF+1,X  ;SHOVE DOWN DISPLAY BUFFER
1324  89F7  9D 40 A6        STA DISBUF,X
1325  89FA  E8              INX
1326  89FB  E0 05           CPX #5
1327  89FD  D0 F5           BNE OUD3
1328  89FF  68              PLA
1329  8A00  8D 45 A6        STA RDIG
1330  8A03  4C C4 81  EXITOD JMP RESALL
1331  8A06  48        TEXT  PHA             ;UPDATE SCOPE BUFFER
1332  8A07  8A              TXA
1333  8A08  48              PHA
1334  8A09  A2 1E           LDX #$1E
1335  8A0B  BD 00 A6  TXTMOV LDA SCPBUF,X
1336  8A0E  9D 01 A6        STA SCPBUF+1,X
1337  8A11  CA              DEX
1338  8A12  10 F7           BPL TXTMOV
1339  8A14  68              PLA
1340  8A15  AA              TAX
1341  8A16  68              PLA
1342  8A17  8D 00 A6        STA SCPBUF
1343  8A1A  60              RTS
1344  8A1B            ;
1345  8A1B            ;***
1346  8A1B            ;*** TERMINAL I/O
1347  8A1B            ;***
1348  8A1B  20 88 81  INCHR  JSR SAVER     ;INPUT CHAR
1349  8A1E  20 41 8A        JSR INJINV
1350  8A21  29 7F           AND #$7F
1351  8A23  C9 61           CMP #$61
1352  8A25  90 06           BCC INRT1
1353  8A27  C9 7B           CMP #$7B
1354  8A29  B0 02           BCS INRT1
1355  8A2B  29 DF           AND #$DF
1356  8A2D  C9 0F  INRT1    CMP #$0F        ;CTL O ?
1357  8A2F  D0 0B           BNE INRT2
1358  8A31  AD 53 A6        LDA TECHO
1359  8A34  49 40           EOR #$40        ;TOGGLE CTL O BIT
1360  8A36  8D 53 A6        STA TECHO
1361  8A39  18              CLC
1362  8A3A  90 E2           BCC INCHR+3     ;GO GET ANOTHER CHAR
1363  8A3C  C9 0D  INRT2    CMP #$0D        ;CARRIAGE RETURN?
1364  8A3E  4C B8 81        JMP RESXAF
1365  8A41  6C 61 A6  INJINV JMP (INVEC+1)
1366  8A44  20 09 83  NBASOC JSR NIBASC
1367  8A47  20 88 81  OUTCHR JSR SAVER
1368  8A4A  2C 53 A6        BIT TECHO       ;LOOK AT CTL O FLAG
1369  8A4D  70 03           BVS *+5
1370  8A4F  20 55 8A        JSR INJOUV
1371  8A52  4C C4 81        JMP RESALL
1372  8A55  6C 64 A6  INJOUV JMP (OUTVEC+1)
1373  8A58  20 88 81  INTCHR JSR SAVER     ;IN TERMINAL CHAR
1374  8A5B  A9 00           LDA #0
1375  8A5D  85 F9           STA $F9
1376  8A5F  AD 02 A4  LOOK   LDA PBDA       ;FIND LEADING EDGE
```

```
LINE # LOC      CODE        LINE

1377  8A62  2D 54 A6          AND TOUTFL
1378  8A65  38                SEC
1379  8A66  E9 40              SBC #$40
1380  8A68  90 F5              BCC LOOK
1381  8A6A  20 E9 8A    TIN    JSR DLYH          ;TERMINAL BIT
1382  8A6D  AD 02 A4          LDA PBDA
1383  8A70  2D 54 A6          AND TOUTFL
1384  8A73  38                SEC
1385  8A74  E9 40              SBC #$40          ;OR BITS 6,7 (TTY,CRT)
1386  8A76  2C 53 A6          BIT TECHO         ;ECHO BIT?
1387  8A79  10 06              BPL DMY1
1388  8A7B  20 D4 8A          JSR OUT
1389  8A7E  4C 87 8A          JMP SAVE
1390  8A81  A0 07       DMY1   LDY #7
1391  8A83  88          TLP1   DEY
1392  8A84  D0 FD              BNE TLP1
1393  8A86  EA                 NOP
1394  8A87  66 F9       SAVE   ROR $F9
1395  8A89  20 E9 8A          JSR DLYH
1396  8A8C  48                 PHA               ;TIMING
1397  8A8D  B5 00              LDA 0,X
1398  8A8F  68                 PLA
1399  8A90  90 D8              BCC TIN
1400  8A92  20 E9 8A          JSR DLYH
1401  8A95  18                 CLC
1402  8A96  20 D4 8A          JSR OUT
1403  8A99  A5 F9              LDA $F9
1404  8A9B  49 FF              EOR #$FF
1405  8A9D  4C B8 81          JMP RESXAF
1406  8AA0  85 F9       TOUT   STA $F9           ;TERMINAL CHR OUT
1407  8AA2  20 88 81          JSR SAVER
1408  8AA5  20 E9 8A          JSR DLYH
1409  8AA8  A9 30              LDA #$30
1410  8AAA  8D 03 A4          STA PBDA+1
1411  8AAD  A5 F9              LDA $F9
1412  8AAF  A2 0B              LDX #$0B
1413  8AB1  49 FF              EOR #$FF
1414  8AB3  38                 SEC
1415  8AB4  20 D4 8A    OUTC   JSR OUT
1416  8AB7  20 E6 8A          JSR DLYF
1417  8ABA  A0 06              LDY #$06
1418  8ABC  88          PHAKE  DEY
1419  8ABD  D0 FD              BNE PHAKE
1420  8ABF  EA                 NOP
1421  8AC0  4A                 LSR A
1422  8AC1  CA                 DEX
1423  8AC2  D0 F0              BNE OUTC
1424  8AC4  A5 F9              LDA $F9
1425  8AC6  C9 0D              CMP #$0D
1426  8AC8  F0 04              BEQ GOPAD
1427  8ACA  C9 0A              CMP #$0A
1428  8ACC  D0 03              BNE LEAVE
1429  8ACE  20 32 8B    GOPAD  JSR PAD
1430  8AD1  4C C4 81    LEAVE  JMP RESALL
1431  8AD4  48          OUT    PHA               ;TERMINAL BIT OUT
```

```
LINE # LOC      CODE        LINE

1432  8AD5  AD 02 A4           LDA PBDA
1433  8AD8  29 0F              AND #$0F
1434  8ADA  90 02              BCC OUTONE
1435  8ADC  09 30              ORA #$30
1436  8ADE  2D 54 A6    OUTONE AND TOUTFL       ;MASK OUTPUT
1437  8AE1  8D 02 A4           STA PBDA
1438  8AE4  68                 PLA
1439  8AE5  60                 RTS
1440  8AE6
1441  8AE6  20 E9 8A    DLYF   JSR DLYH         ;DELAY FULL
1442  8AE9  08          DLYH   PHP              ;DELAY HALF
1443  8AEA  48                 PHA
1444  8AEB  8A                 TXA
1445  8AEC  48                 PHA
1446  8AED  98                 TYA
1447  8AEE  AE 51 A6           LDX SDBYT
1448  8AF1  A0 03       DLYX   LDY #3
1449  8AF3  88          DLYY   DEY
1450  8AF4  D0 FD              BNE DLYY
1451  8AF6  CA                 DEX
1452  8AF7  D0 F8              BNE DLYX
1453  8AF9  A8                 TAY
1454  8AFA  68                 PLA
1455  8AFB  AA                 TAX
1456  8AFC  68                 PLA
1457  8AFD  28                 PLP
1458  8AFE  60                 RTS
1459  8AFF  A9 00       BAUD   LDA #0           ;DETERMINE BAUD RATE ON PB7
1460  8B01  A8                 TAY
1461  8B02  AD 02 A4    SEEK   LDA PBDA
1462  8B05  0A                 ASL A
1463  8B06  B0 FA              BCS SEEK
1464  8B08  20 27 8B    CLEAR  JSR INK
1465  8B0B  90 FB              BCC CLEAR
1466  8B0D  20 27 8B    SET    JSR INK
1467  8B10  B0 FB              BCS SET
1468  8B12  8C 51 A6           STY SDBYT
1469  8B15  BD 63 8C    DEAF   LDA DECPTS,X
1470  8B18  CD 51 A6           CMP SDBYT
1471  8B1B  B0 07              BCS AGAIN
1472  8B1D  BD 69 8C           LDA STDVAL,X    ;LOAD CLOSEST STD VALUE
1473  8B20  8D 51 A6           STA SDBYT
1474  8B23  60                 RTS
1475  8B24  E8          AGAIN  INX
1476  8B25  10 EE              BPL DEAF
1477  8B27  C8          INK    INY
1478  8B28  A2 1C              LDX #$1C
1479  8B2A  CA          INK1   DEX
1480  8B2B  D0 FD              BNE INK1
1481  8B2D  AD 02 A4           LDA PBDA
1482  8B30  0A                 ASL A
1483  8B31  60                 RTS
1484  8B32  AE 50 A6    PAD    LDX PADBIT       ;PAD CARRIAGE RETURN
1485  8B35  20 E6 8A    PAD1   JSR DLYF
1486  8B38  CA                 DEX
```

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LINE # LOC      CODE        LINE

1487  8B39  D0 FA             BNE PAD1
1488  8B3B  60               RTS
1489  8B3C  20 A3 89   TSTAT  JSR KSCONF      ;SEE IF BREAK KEY DOWN
1490  8B3F  2C 02 A4         BIT PBDA
1491  8B42  18               CLC
1492  8B43  10 01            BPL *+3
1493  8B45  38               SEC
1494  8B46  60               RTS
1495  8B47  20 0F 87         JSR DIFF1
1496  8B4A                 ; ***
1497  8B4A                 ; *** RESET - TURN OFF POR, INIT SYS RAM, ENTER MONITOR
1498  8B4A                 ; ***
1499  8B4A                 ;
1500  8B4A  A2 FF      RESET  LDX #$FF
1501  8B4C  9A               TXS              ;INIT STACK PTR
1502  8B4D  A9 CC      POR    LDA #$CC
1503  8B4F  8D 0C A0         STA PCR1         ;DISABLE POR, TAPE OFF
1504  8B52  A9 04            LDA #4
1505  8B54  48               PHA
1506  8B55  28               PLP              ;INIT F, DISABLE IRQ DURING DFTXFF
1507  8B56  20 86 8B         JSR ACCESS       ;UN WRITE PROT SYS RAM
1508  8B59  A2 5F      DFTXFR LDX #$5F         ;INIT SYS RAM (EXCPT SCPBUF)
1509  8B5B  BD A0 8F         LDA DFTBLK,X
1510  8B5E  9D 20 A6         STA RAM,X
1511  8B61  CA               DEX
1512  8B62  10 F7            BPL DFTXFR+2
1513  8B64  A9 07      NEWDEV LDA #7           ;CHANGE DEVC/BAUD RATE
1514  8B66  20 47 8A         JSR OUTCHR       ;BEEP
1515  8B69  20 A3 89   SWITCH JSR KSCONF       ;KEYBOARD OR TERMINAL?
1516  8B6C  20 26 89   SWLP   JSR KEYQ+3
1517  8B6F  D0 0B            BNE MONENT
1518  8B71  2C 02 A4         BIT PBDA
1519  8B74  10 F6            BPL SWLP
1520  8B76  20 B7 8B         JSR VECSW        ;SWITCH VECTORS
1521  8B79  20 FF 8A         JSR BAUD
1522  8B7C  A2 FF      MONENT LDX #$FF         ;MONITOR ENTRY
1523  8B7E  9A               TXS
1524  8B7F  D8               CLD
1525  8B80  20 86 8B         JSR ACCESS       ;UNWRITE PROT MONITOR RAM
1526  8B83  4C 03 80         JMP WARM
1527  8B86  20 88 81   ACCESS JSR SAVER        ;UN WRITE PROT SYS RAM
1528  8B89  AD 01 AC         LDA OR3A
1529  8B8C  09 01            ORA #1
1530  8B8E  8D 01 AC   ACC1   STA OR3A
1531  8B91  AD 03 AC         LDA DDR3A
1532  8B94  09 01            ORA #1
1533  8B96  8D 03 AC         STA DDR3A
1534  8B99  4C C4 81         JMP RESALL
1535  8B9C  20 88 81   NACCES JSR SAVER        ;WRITE PROT SYS RAM
1536  8B9F  AD 01 AC         LDA OR3A
1537  8BA2  29 FE            AND #$FE
1538  8BA4  18               CLC
1539  8BA5  90 E7            BCC ACC1
1540  8BA7  20 86 8B   TTY    JSR ACCESS       ;UN WRITE PROT RAM
1541  8BAA  A9 D5            LDA #$D5         ;110 BAUD
```

```
LINE # LOC      CODE        LINE

1542  8BAC  8D 51 A6            STA SDBYT
1543  8BAF  AD 54 A6            LDA TOUTFL
1544  8BB2  09 40               ORA #$40
1545  8BB4  8D 54 A6            STA TOUTFL
1546  8BB7  20 86 8B     VECSW  JSR ACCESS       ;UN WRITE PROT RAM
1547  8BBA  A2 08               LDX #$8
1548  8BBC  BD 6F 8C     SWLP2  LDA TRMTBL,X
1549  8BBF  9D 60 A6            STA INVEC,X
1550  8BC2  CA                  DEX
1551  8BC3  10 F7               BPL SWLP2
1552  8BC5  60                  RTS
1553  8BC6               ;
1554  8BC6               ;***
1555  8BC6               ;*** TABLES (I/O CONFIGURATIONS, KEY CODES, ASCII CODES)
1556  8BC6               ;***
1557  8BC6  00           VALS   .BYT $00,$80,$08,$37 ;KB SENSE, A=1
1557  8BC7  80
1557  8BC8  08
1557  8BC9  37
1558  8BCA  00                  .BYT $00,$7F,$00,$30 ;KB LRN, A=5
1558  8BCB  7F
1558  8BCC  00
1558  8BCD  30
1559  8BCE  00                  .BYT $00,$FF,$00,$3F ;SCAN DSP, A=9
1559  8BCF  FF
1559  8BD0  00
1559  8BD1  3F
1560  8BD2  00                  .BYT $00,$00,$07,$3F ;BEEP, A=D
1560  8BD3  00
1560  8BD4  07
1560  8BD5  3F
1561  8BD6               VALSP2 =VALS+2
1562  8BD6               SYM    =*               ;KEY CODES RETURNED BY LRNKEY
1563  8BD6               TABLE=*
1564  8BD6  01                  .BYT $01         ;0/U0
1565  8BD7  41                  .BYT $41         ;1/U1
1566  8BD8  81                  .BYT $81         ;2/U2
1567  8BD9  C1                  .BYT $C1         ;3/U3
1568  8BDA  02                  .BYT $02         ;4/U4
1569  8BDB  42                  .BYT $42         ;5/U5
1570  8BDC  82                  .BYT $82         ;6/U6
1571  8BDD  C2                  .BYT $C2         ;7/U7
1572  8BDE  04                  .BYT $04         ;8/JMP
1573  8BDF  44                  .BYT $44         ;9/VER
1574  8BE0  84                  .BYT $84         ;A/ASCII
1575  8BE1  C4                  .BYT $C4         ;B/BLK MOV
1576  8BE2  08                  .BYT $08         ;C/CALC
1577  8BE3  48                  .BYT $48         ;D/DEP
1578  8BE4  88                  .BYT $88         ;E/EXEC
1579  8BE5  C8                  .BYT $C8         ;F/FILL
1580  8BE6  10                  .BYT $10         ;CR/SD
1581  8BE7  50                  .BYT $50         ;-/+
1582  8BE8  90                  .BYT $90         ;>/<
1583  8BE9  D0                  .BYT $D0         ;SHIFT
1584  8BEA  20                  .BYT $20         ;GO/LP
```

```
LINE # LOC     CODE        LINE

1585  8BEB  60                    .BYT $60        ;REG/SP
1586  8BEC  A0                    .BYT $A0        ;MEM/WP
1587  8BED  00                    .BYT $00        ;L2/L1
1588  8BEE  40                    .BYT $40        ;S2/S1
1589  8BEF              ASCIM1 =*-1
1590  8BEF              ASCII  =*                 ;ASCII CODES AND HASH CODES
1591  8BEF  30                    .BYT $30        ;ZERO
1592  8BF0  31                    .BYT $31        ;ONE
1593  8BF1  32                    .BYT $32        ;TWO
1594  8BF2  33                    .BYT $33        ;THREE
1595  8BF3  34                    .BYT $34        ;FOUR
1596  8BF4  35                    .BYT $35        ;FIVE
1597  8BF5  36                    .BYT $36        ;SIX
1598  8BF6  37                    .BYT $37        ;SEVEN
1599  8BF7  38                    .BYT $38        ;EIGHT
1600  8BF8  39                    .BYT $39        ;NINE
1601  8BF9  41                    .BYT $41        ;A
1602  8BFA  42                    .BYT $42        ;B
1603  8BFB  43                    .BYT $43        ;C
1604  8BFC  44                    .BYT $44        ;D
1605  8BFD  45                    .BYT $45        ;E
1606  8BFE  46                    .BYT $46        ;F
1607  8BFF  0D                    .BYT $0D        ;CR
1608  8C00  2D                    .BYT $2D        ;DASH
1609  8C01  3E                    .BYT $3E        ;>
1610  8C02  FF                    .BYT $FF        ;SHIFT
1611  8C03  47                    .BYT $47        ;G
1612  8C04  52                    .BYT $52        ;R
1613  8C05  4D                    .BYT $4D        ;M
1614  8C06  13                    .BYT $13        ;L2
1615  8C07  1E                    .BYT $1E        ;S2
1616  8C08              ; KB UPPER CASE
1617  8C08  14                    .BYT $14        ;U0
1618  8C09  15                    .BYT $15        ;U1
1619  8C0A  16                    .BYT $16        ;U2
1620  8C0B  17                    .BYT $17        ;U3
1621  8C0C  18                    .BYT $18        ;U4
1622  8C0D  19                    .BYT $19        ;U5
1623  8C0E  1A                    .BYT $1A        ;U6
1624  8C0F  1B                    .BYT $1B        ;U7
1625  8C10  4A                    .BYT $4A        ;J
1626  8C11  56                    .BYT $56        ;V
1627  8C12  FE                    .BYT $FE        ;ASCII
1628  8C13  42                    .BYT $42        ;B
1629  8C14  43                    .BYT $43        ;C
1630  8C15  44                    .BYT $44        ;D
1631  8C16  45                    .BYT $45        ;E
1632  8C17  46                    .BYT $46        ;F
1633  8C18  10                    .BYT $10        ;SD
1634  8C19  2B                    .BYT $2B        ;+
1635  8C1A  3C                    .BYT $3C        ;<
1636  8C1B  00                    .BYT $00        ;SHIFT
1637  8C1C  11                    .BYT $11        ;LP
1638  8C1D  1C                    .BYT $1C        ;SP
1639  8C1E  57                    .BYT $57        ;W
```

```
LINE # LOC     CODE        LINE

1640  8C1F  12                    .BYT $12          ;L1
1641  8C20  1D                    .BYT $1D          ;S1
1642  8C21  2E                    .BYT $2E          ;.
1643  8C22  20                    .BYT $20          ;BLANK
1644  8C23  3F                    .BYT $3F          ;?
1645  8C24  50                    .BYT $50          ;P
1646  8C25  07                    .BYT $07          ;BELL
1647  8C26  63                    .BYT $63          ;SMALL C
1648  8C27  2F                    .BYT $2F          ;/
1649  8C28  2A                    .BYT $2A          ;*
1650  8C29                  ; SEGMENT CODES FOR ON-BOARD DISPLAY
1651  8C29                  SEGSM1 =*-1
1652  8C29  3F                    .BYT $3F          ;ZERO
1653  8C2A  06                    .BYT $06          ;ONE
1654  8C2B  5B                    .BYT $5B          ;TWO
1655  8C2C  4F                    .BYT $4F          ;THREE
1656  8C2D  66                    .BYT $66          ;FOUR
1657  8C2E  6D                    .BYT $6D          ;FIVE
1658  8C2F  7D                    .BYT $7D          ;SIX
1659  8C30  07                    .BYT $07          ;SEVEN
1660  8C31  7F                    .BYT $7F          ;EIGHT
1661  8C32  67                    .BYT $67          ;NINE
1662  8C33  77                    .BYT $77          ;A
1663  8C34  7C                    .BYT $7C          ;B
1664  8C35  39                    .BYT $39          ;C
1665  8C36  5E                    .BYT $5E          ;D
1666  8C37  79                    .BYT $79          ;E
1667  8C38  71                    .BYT $71          ;F
1668  8C39  F0                    .BYT $F0          ;CR
1669  8C3A  40                    .BYT $40          ;DASH
1670  8C3B  70                    .BYT $70          ;>
1671  8C3C  00                    .BYT $00          ;SHIFT
1672  8C3D  6F                    .BYT $6F          ;G
1673  8C3E  50                    .BYT $50          ;R
1674  8C3F  54                    .BYT $54          ;M
1675  8C40  38                    .BYT $38          ;L2
1676  8C41  6D                    .BYT $6D          ;S2
1677  8C42  01                    .BYT $01          ;U0
1678  8C43  08                    .BYT $08          ;U1
1679  8C44  09                    .BYT $09          ;U2
1680  8C45  30                    .BYT $30          ;U3
1681  8C46  36                    .BYT $36          ;U4
1682  8C47  5C                    .BYT $5C          ;U5
1683  8C48  63                    .BYT $63          ;U6
1684  8C49  03                    .BYT $03          ;U7
1685  8C4A  1E                    .BYT $1E          ;J
1686  8C4B  72                    .BYT $72          ;V
1687  8C4C  77                    .BYT $77          ;A
1688  8C4D  7C                    .BYT $7C          ;B
1689  8C4E  39                    .BYT $39          ;C
1690  8C4F  5E                    .BYT $5E          ;D
1691  8C50  79                    .BYT $79          ;E
1692  8C51  71                    .BYT $71          ;F
1693  8C52  6D                    .BYT $6D          ;SD
1694  8C53  76                    .BYT $76          ;+
```

```
LINE # LOC      CODE        LINE

1695  8C54  46                    .BYT $46          ;<
1696  8C55  00                    .BYT $00          ;SHIFT
1697  8C56  38                    .BYT $38          ;LP
1698  8C57  6D                    .BYT $6D          ;SP
1699  8C58  1C                    .BYT $1C          ;W
1700  8C59  38                    .BYT $38          ;L1
1701  8C5A  6D                    .BYT $6D          ;S1
1702  8C5B  80                    .BYT $80          ;.
1703  8C5C  00                    .BYT $00          ;SPACE
1704  8C5D  53                    .BYT $53          ;?
1705  8C5E  73                    .BYT $73          ;P
1706  8C5F  49                    .BYT $49          ;BELL
1707  8C60  5C                    .BYT $5C          ;SMALL C
1708  8C61  52                    .BYT $52          ;/
1709  8C62  63                    .BYT $63          ;
1710  8C63  97              DECPTS .BYT $97,$3D,$1F,$10,$08,$00 ; TO DETERMINE BAUD I
1710  8C64  3D
1710  8C65  1F
1710  8C66  10
1710  8C67  08
1710  8C68  00
1711  8C69  D5 4C          STDVAL .DBY $D54C,$2410,$0601    ;STD VALS FOR BAUD RATES
1711  8C6B  24 10
1711  8C6D  06 01
1712  8C6F                 ; 110,300,600,1200,2400,4800 BAUD
1713  8C6F  4C 58 8A       TRMTBL JMP INTCHR        ;ALTERNATE VCTRS FOR TIO
1714  8C72  4C A0 8A              JMP TOUT
1715  8C75  4C 3C 8B              JMP TSTAT
1716  8C78                 LENTRY =*                ;LINK TO AUDIO CASSETTE
1717  8C78                 SENTRY =*+$20F
1718  8C78                 ;***
1719  8C78                 ;*** DEFAULT TABLE
1720  8C78                 ;***
1721  8C78                        *=$8FA0
1722  8FA0                 DFTBLK=*
1723  8FA0  00 C0                 .WORD $C000      ;BASIC  *** JUMP TABLE
1724  8FA2  A7 8B                 .WORD TTY
1725  8FA4  64 8B                 .WORD NEWDEV
1726  8FA6  00 00                 .WORD $0000      ;PAGE ZERO
1727  8FA8  00 02                 .WORD $0200
1728  8FAA  00 03                 .WORD $0300
1729  8FAC  00 C8                 .WORD $C800
1730  8FAE  00 D0                 .WORD $D000
1731  8FB0  00 00                 .DBY $0000,$0000,$0000,$0000  ;SCR0 - SCR7
1731  8FB2  00 00
1731  8FB4  00 00
1731  8FB6  00 00
1732  8FB8  00 00                 .DBY $0000,$0000,$0000,$0000 ;SCR8 - SCRF
1732  8FBA  00 00
1732  8FBC  00 00
1732  8FBE  00 00
1733  8FC0  00                    .BYT $00,$00,$6D,$6E,$86,$3F ;DISP BUFFER (SY1.0)
1733  8FC1  00
1733  8FC2  6D
1733  8FC3  6E
```

```
LINE # LOC     CODE        LINE

1733  8FC4  86
1733  8FC5  3F
1734  8FC6  00                    .BYT $00,$00,$00 ;NOT USED
1734  8FC7  00
1734  8FC8  00
1735  8FC9  00                    .BYT $00         ;PARNR
1736  8FCA  00 00                 .DBYT $0000,$0000,$0000 ;PARMS
1736  8FCC  00 00
1736  8FCE  00 00
1737  8FD0  01                    .BYT $01         ;PADBIT
1738  8FD1  4C                    .BYT $4C         ;SDBYT
1739  8FD2  00                    .BYT $00         ;ERCNT
1740  8FD3  80                    .BYT $80         ;TECHO
1741  8FD4  B0                    .BYT $B0         ;TOUTFL
1742  8FD5  00                    .BYT $00         ;KSHFL
1743  8FD6  00                    .BYT $00         ;TV
1744  8FD7  00                    .BYT $00         ;LSTCOM
1745  8FD8  10                    .BYT $10         ;MAXRC
1746  8FD9  4A 8B                 .WORD RESET      ;USER REG'S
1747  8FDB  FF                    .BYT $FF         ;STACK
1748  8FDC  00                    .BYT $00         ;FLAGS
1749  8FDD  00                    .BYT $00         ;A
1750  8FDE  00                    .BYT $00         ;X
1751  8FDF  00                    .BYT $00         ;Y
1752  8FE0                  ; VECTORS
1753  8FE0  4C BE 89              JMP HKEY         ;INVEC
1754  8FE3  4C 00 89              JMP HDOUT        ;OUTVEC
1755  8FE6  4C 6A 89              JMP KYSTAT       ;INSVEC
1756  8FE9  00                    .BYT $00,$00,$00 ;NOT USED
1756  8FEA  00
1756  8FEB  00
1757  8FEC  4C D1 81              JMP M1           ;UNRECOGNIZED CHAR (ERR RTN)
1758  8FEF  4C 06 89              JMP SCAND        ;SCNVEC
1759  8FF2  7E 88                 .WORD RIN        ;IN PTR FOR EXEC FROM RAM
1760  8FF4  C0 80                 .WORD TRCOFF     ;USER TRACE VECTOR
1761  8FF6  4A 80                 .WORD SVBRK      ;BRK
1762  8FF8  29 80                 .WORD SVIRQ      ;USER IRQ
1763  8FFA  9B 80                 .WORD SVNMI      ;NMI
1764  8FFC  4A 8B                 .WORD RESET      ;RESET
1765  8FFE  0F 80                 .WORD IRQBRK     ;IRQ
1766  9000                        .END

ERRORS = 0000 <0000>
```

```
SYMBOL    VALUE  LINE DEFINED        CROSS-REFERENCES

ACCESS    8B86       1527   123  129  137  177  191 1507 1525 1540 1546
ACC1      8B8E       1530  1539
ADVCK     81CB        336   581  599
AGAIN     8B24       1475  1471
AR        A65D         59   152  186  616
ASCII     8BEF       1590  1259
ASCIM1    8BEE       1589  1313
ASCNIB    8275        412   344  352  394
BADDY     848B        666   660
BAUD      8AFF       1459  1521
BEEP      8972       1266  1193
BEEPP3    8975       1267  1304
BEEPP5    8977       1268  1286
BE1       897C       1270  1277
BE2       8995       1280  1272 1275
BE3       8997       1281  1282
BLK3      8739        991   976
BLP       875E       1007  1013 1014
BLP1      879D       1035  1042
BMOVE     87B7       1048  1007 1035
BRT       87CC       1058  1052
BRTT      87C1       1053   985
BZPARM    8395        559   261
B1        87AF       1043   987  990 1005 1012 1015 1041
B1PARM    84DA        699   264
B2        8772       1016  1006
B2PARM    8619        858   267
B3PARM    8714        971   270
CALC3     8827       1103   857  970 1085
CHKSAD    82DD        463   676  887  955
CLEAR     8B08       1464  1465
COMINB    81D6        342   569
COMMA     833A        511   342  503  732
COMPAR    82CA        455   444  446
CONFIG    89A5       1288  1211 1230 1268
CON1      89AB       1291  1297
CRCHK     8204        364   362  363
CRLF      834D        521   147  219  277  497  564  587  604  622  784  905
                            926 1105
CRLFSZ    8316        497   706  731  882
C1        882B       1105  ****
DBNEW     80F6        212   204
DBOFF     80D3        198   146  180  194
DBON      80E4        205   196
DDR1B     A002         91  ****
DDR3A     AC03         89   202  209  211  212  214  854 1531 1533
DEAF      8B15       1469  1476
DECCMP    82BE        449   761  899 1040
DECPTS    8C63       1710  1469
DELAY     835A        528   188
DEPBYT    84E8        709   718
DEPEC     850E        726   720
DEPES     8553        759   722
DEPN      84F9        716   714  723  725
```

```
SYMBOL   VALUE  LINE DEFINED        CROSS-REFERENCES

DEPZ     84A7        677   620
DEP1     84DA        703   ****
DETBRK   801B        113   ****
DETIRQ   8022        118   112
DFTBLK   8FA0       1722  1509
DFTXFR   8B59       1508  1512
DIFFL    86FD        958   ****
DIFFL2   8710        969   ****
DIFFZ    86FA        957   923
DIFF1    870F        968   964  1495
DISBUF   A640         27  1214  1323  1324
DISPAT   814A        256    99
DLYF     8AE6       1441  1416  1485
DLYH     8AE9       1442  1381  1395  1400  1408  1441
DLYO     8383        544   539
DLYX     8AF1       1448  1452
DLYY     8AF3       1449  1450
DLY1     8368        533   536
DLY2     8371        537   543
DL1      835D        529   ****
DMY1     8A81       1390  1387
ERCNT    A652         43   624   632   649   653   667   671   673   979   995  1043
                          1053  1057
ERMSG    8171        275   100
EXEVEC   A672         74  1130  1135  1137
EXE3     8851       1125  1104
EXITCP   82D9        461   458
EXITG    88FF       1207  1203
EXITGK   88CC       1183  1171
EXITLP   843F        634   ****
EXITM1   8577        780   745
EXITNB   8315        496   494
EXITOD   8A03       1330  1311  1317  1320
EXITRG   83C1        579   598
EXRGP1   83C2        580   582
EXWRAP   82BD        448   447
EZPARM   84D7        698   695
E1PARM   8616        857   842
E2PARM   8711        970   919
E3PARM   88AC       1164  1126
FILL3    8714        975   ****
FOUND    8960       1255  1250
FR       A65C         58   164   612
F1       8723        981   988   989
F2       8737        990   ****
F3       872E        986   984
GETCOM   80FF        219    98   223   246
GETC1    8107        222   225   227
GETKEY   88AF       1168  1299
GETSGS   89EA       1318  1314
GK       88CF       1184  1169  1172  1179
GK1      88D4       1186  1187  1189  1206
GK2      88E4       1194  1195  1198
GOOD     81F3        355   360
GOPAD    8ACE       1429  1426
GO2      83F7        604   ****
GOZ      83F3        602   563
```

SYMBOL	VALUE	LINE DEFINED	CROSS-REFERENCES
GO1	8579	782	729
GO1ENT	83FA	605	197
HASHL	812F	240	234
HASHUS	8133	242	230 232 241
HDOUT	8900	1208	1754 .
HIPN	816E	271	257 269
HKEY	89BE	1299	1753
IDISP	8053	145	127 136 184
IJSCNV	8903	1209	537 1186
INBYTE	81D9	343	572 657 661 666 675 710
INCCMP	82B2	443	654 716 742 889 946 986 1011 1091
INCHR	8A1B	1348	222 245 252 343 351 359 382 626 1162 1362
INCP3	8293	429	1070 1081
INJINV	8A41	1365	1349
INJISV	8392	554	548 550
INJOUV	8A55	1372	1370
INK	8B27	1477	1464 1466
INK1	8B2A	1479	1480
INRT1	8A2D	1356	1352 1354
INRT2	8A3C	1363	1357
INSTAT	8386	548	538 896 944
INST1	838B	550	551
INST2	8391	553	549
INSVEC	A666	67	554
INTCHR	8A58	1373	1713
INVEC	A660	65	1128 1133 1136 1138 1158 1160 1365 1549
IRQBRK	800F	105	1765
IRQVEC	A67E	82	****
JTABLE	A620	9	822 824
JUMP1	85B4	808	797
JUM2	85E5	833	812
KEYQ	8923	1223	1194 1197 1261 1516
KSCONF	89A3	1287	1223 1278 1489 1515
KSHFL	A655	48	1185 1205 1257
KYSTAT	896A	1261	1755
LDBYTE	84A1	675	629 637 640 643
LEAVE	8AD1	1430	1428
LENTRY	8C78	1716	693 836 1083
LK1	8944	1237	1234
LK2	894A	1240	1238
LK3	8956	1249	1252
LOCM8	8569	772	758
LOCP8	855B	764	754
LOOK	8A5F	1376	1380
LPGD	846D	654	648
LPZ	8429	625	641 664 670 674
LPZB	8417	618	603
LP1	842C	626	628
LRNKEY	892C	1227	1188
LSTCOM	A657	50	235 244 248 258
L1J	84CC	693	697
L1ZB	84C6	690	684
L11B	85D7	826	809
L11C	85DD	829	840
L11D	85E9	835	917
L12B	8688	911	879 915
L12C	868C	913	****

SYMBOL	VALUE	LINE DEFINED	CROSS-REFERENCES
L2ZB	84CF	694	691
L21B	85EF	837	827
L23P	87EE	1076	1073
MAXRC	A658	51	927 929
MEMZ	84AE	680	678
MEM1	8510	728	704
MEM2	862F	873	863
MEM3	8801	1084	1077
MEM3C	8808	1087	877 1093 1094
MEM3D	8811	1091	1100
MEM3E	881C	1097	1090
MEM3EX	881A	1095	1092
MEM3F	8826	1102	1098
MONENT	8B7C	1522	97 1517
MONITR	8000	97	****
MORED	8454	643	656
MORED2	86D2	941	949
M1	81D1	339	337 1757
M12	8159	262	260
M13	8160	265	263
M14	8167	268	266
M15	81B7	314	275
M21	8239	387	384
M22	824A	394	386
M23	8251	397	400
M24	8267	406	393 395
M25	826F	409	407
M26	8289	422	415 417
M27	828D	425	419
M28	828F	426	421
M29	8292	428	413
M32	82C8	454	450
M33	82EB	470	468
M34	83C8	583	577
M35	83CA	584	597 600
M36	83EB	598	595
M42	8566	770	768
M43	8574	778	776
NACCES	8B9C	1535	605 785 813
NBASOC	8A44	1366	485 487 591
NBELL	89CD	1305	1303
NEWDEV	8B64	1513	1725
NEWLN	84E1	706	679 719
NEWLOC	8517	731	682 744 748 763 771 779 1097
NH3	83BF	578	570 573
NH41	8501	720	711
NH42	8537	745	736
NIBALF	8313	495	492
NIBASC	8309	490	1366
NMIVEC	A67A	80	****
NOBEEP	899B	1284	1196
NOKEY	895E	1253	1236
NOTCR	83C3	581	578
NR10	8408	611	795 825
NUREC	8443	636	631
NXTLOC	8531	742	740 750 752
NXTRG	83D2	588	****

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SYMBOL   VALUE  LINE DEFINED        CROSS-REFERENCES

OBCMIN   81D3        341   594  735
OBCRLF   834A        520   187
OCMCK    8325        503   895  904
OPCCOM   8337        510   148  185
OR1B     A000         90  ****    .
OR3A     AC01         88    89  198  201  205  208  852 1528 1530 1536
OUD1     89DE       1312  1307
OUD2     89E0       1313  1316
OUD3     89F4       1323  1327
OUT      8AD4       1431  1388 1402 1415
OUTBYT   82FA        479   284  341  477  505  520  888  956
OUTC     8AB4       1415  1423
OUTCHR   8A47       1367   150  221  279  281  502  517  523  525  566  589
                          934 1154 1514
OUTDSP   89C1       1300  1208
OUTONE   8ADE       1436  1434
OUTPC    82EE        473   510  568
OUTQM    8320        501   715  741
OUTSZ    8319        498  ****
OUTVEC   A663         66  1372
OUTXAH   82F4        475   500  908  952 1122
OUT1     81FE        361   358
OUT2     8201        363   353
OUT4     81F5        357   345
PAD      8B32       1484  1429
PADA     A400         86  1215 1217 1224 1235 1294
PADBIT   A650         41  1484
PAD1     8B35       1485  1487
PARFIL   822E        382   405
PARM     8220        377   239
PARNR    A649         30   259  379  389  390  408
PBDA     A402         87  1216 1231 1271 1274 1292 1376 1382 1410 1432 1437
                         1461 1481 1490 1518
PCHR     A65A         56   134  162  474  576  593  596  608
PCLR     A659         55   132  159  473  574  610
PCR1     A00C         92  1503
PHAKE    8ABC       1418  1419
PM1      822B        381   392
POR      8B4D       1502  ****
PRM10    820A        368   375
PRVLOC   8555        761   756
PSHOVE   8208        367   237  238  381  834  835
PTRIN    8872       1139  1131
P1H      A64F         40   373  999 1111
P1L      A64E         39   372  876  980  997 1062 1078 1087 1108
P2H      A64D         38   371  433  804  865 1033 1112
P2L      A64C         37   370  435  799  869  875  913 1031 1109
P2SCR    829C        433   880  922  977  996 1086
P3H      A64B         36   369  398  431  438  457  688  792  803  806  847
                          962 1021 1034 1119 1139
P3L      A64A         35   368  397  401  402  429  440  460  686  794  798
                          802  810  829  843  958 1018 1032 1116 1141
P3SCR    82A7        438   705  730  864 1030
RAM      A620          8  1510
RC       A63D         24   636  655  932  935  948
RDIG     A645         28  1308 1310 1329
REGZ     8395        562  ****
```

```
SYMBOL   VALUE  LINE DEFINED        CROSS-REFERENCES

RESALL   81C4         326   925 1279 1298 1330 1371 1430 1534
RESET    8B4A        1500  1746 1764
RESTIV   8899        1157  1148
RESXAF   81B8         316   411 1156 1163 1183 1364 1405
RESXF    81BE         321   462  544  635
RGBACK   8399         564   586
RIN      887E        1145  1759
RSTVEC   A67C          81  ****
SAVE     8A87        1394  1389
SAVER    8188         289   377  455  529  621  921 1145 1168 1266 1284 1288
                                1300 1348 1367 1373 1407 1527 1535
SAVINT   8064         152   125  131  139  179  193
SCAND    8906        1210  1758
SCNVEC   A66F          70  1209
SCPBUF   A600           7  1335 1336 1342
SCRA     A63A          20  1132 1134 1157 1159
SCRB     A63B          21  ****
SCRC     A63C          22  ****
SCRD     A63D          23    24
SCRE     A63E          25  1178 1182
SCRF     A63F          26  1228 1247
SCR0     A630          10  ****
SCR1     A631          11  ****
SCR2     A632          12  ****
SCR3     A633          13   350  354  380  388  404  406
SCR4     A634          14   571  575
SCR5     A635          15  ****
SCR6     A636          16   466  467  504  507  663  951
SCR7     A637          17   469  508  659  907  950
SCR8     A638          18   532  533  540
SCR9     A639          19   531  534  542
SC1      890D        1213  1222
SC2      891D        1219  1220
SDBYT    A651          42  1447 1468 1470 1473 1542
SEEK     8B02        1461  1463
SEGSM1   8C28        1651  1318
SENTRY   8E87        1717  1071
SET      8B0D        1466  1467
SPACE    8342         515   236  282  514  567  709  724  884  906 1106
SPCP3    8345         517   513
SPC2     833F         514   592
SPEXIT   86A8         925   945  947
SP2B     8698         918   912
SP2C     86A3         923   954
SP2D     86AB         926   924
SP2E     86B8         931   928
SP2F     86BA         932   930
SR       A65B          57   175  606
STDVAL   8C69        1711  1472
STD2     8619         862  ****
STOCOM   8120         235   251
SVBRK    804A         137  1761
SVBYTE   86F4         955   936  938  940  943
SVIRQ    8029         123  1762
SVNMI    809B         177  1763
SWITCH   8B69        1515  ****
SWLP     8B6C        1516  1519
```

SYMBOL	VALUE	LINE DEFINED		CROSS-REFERENCES				
SWLP2	8BBC	1548	1551					
SYM	8BD6	1562	1249					
S1NG	87DE	1068	1080					
S13B	87CD	1059	993					
S13C	87D3	1062	1075					
S23B	87E6	1072	1060					
TABLE	8BD6	1563	****					
TAPERR	848E	667	630	638	644	658	662	665
TECHO	A653	45	1152	1358	1360	1368	1386	
TEXT	8A06	1331	1305					
TIN	8A6A	1381	1399					
TLP1	8A83	1391	1392					
TOUT	8AA0	1406	1714					
TOUTFL	A654	47	1377	1383	1436	1543	1545	
TRACON	80CD	196	189					
TRCOFF	80C0	191	1760					
TRCVEC	A674	75	195					
TRMTBL	8C6F	1713	1548					
TSTAT	8B3C	1489	1715					
TTY	8BA7	1540	1724					
TV	A656	49	181	528				
TVNZ	80AF	185	182					
TXTMOV	8A0B	1335	1338					
UBRKV	A676	77	****					
UBRKVC	A676	76	77					
UIRQV	A678	79	****					
UIRQVC	A678	78	79					
URCVEC	A66C	69	271	698	1164			
USRENT	8035	128	****					
VADDR	8646	882	897					
VALS	8BC6	1557	1293	1561				
VALSP2	8BC8	1561	1291					
VECSW	8BB7	1546	1520					
VERZ	84B5	683	681					
VER1	8596	796	689	783				
VER2	863C	878	807	874				
VOCK	8664	895	****					
V1	866D	899	890	892	903			
V2	864B	884	894					
WARM	8003	98	101	151	190	1526		
WPR1B	85F7	841	838					
WRAP	82B8	446	452					
XR	A65E	60	153	615				
YR	A65F	61	154	614				
ZERCK	832E	506	625	881	957			

```
LINE #  LOC     CODE        LINE

0002   0000              ; AUDIO CASSETTE INTERFACE
0003   0000              ;******
0004   0000              ;****** COPYRIGHT 1978 SYNERTEK SYSTEMS CORPORATION
0005   0000              ;******
0006   0000              ;
0007   0000              ;VARIABLES
0008   0000              ;
0009   0000              OLD     =$F9            ;REMEMBER PREV INPUT LEVEL IN LOA
0010   0000              CHAR    =$FC            ;CHAR ASSY AND DISASSY
0011   0000              MODE    =$FD            ;BIT7=1 IS HS, 0 IS KIM
0012   0000              ;                 ... BIT6=1 IS HS REC W/WRONG ID BEING READ
0013   0000              ;           ... OR NOT YET IN SYNC (NO FRAME ERR)
0014   0000              BUFADL  =$FE            ;RUNNING BUFFER ADR
0015   0000              BUFADH  =$FF
0016   0000              CHKL    =$A636          ;SCR 6
0017   0000              CHKH    =$A637          ;SCR 7
0018   0000              TEMP1   =$A638          ;SCR 8
0019   0000              TEMP2   =$A639          ;SCR 9
0020   0000              ; PARAMETER AREA
0021   0000                      *=$A64A
0022   A64A              P3L     *=*+1           ;END ADDR +1 (LO)
0023   A64B              P3H     *=*+1           ; (HI)
0024   A64C              P2L     *=*+1           ;START ADDR ; (LO)
0025   A64D              P2H     *=*+1           ; (HI)
0026   A64E              P1L     *=*+1           ; ID
0027   A64F              ; CONSTANTS
0028   A64F              ;
0029   A64F              EOT     = $04
0030   A64F              SYN     = $16
0031   A64F              TM1500  =71             ;DELAY CONSTANT FOR OUTBTH
0032   A64F              C1500   =$1F            ;CLOCK LO LATCH FOR 1500 BAUD
0033   A64F              CKIM    =$AE            ;CLOCK LO LATCH FOR KIM
0034   A64F              TPBIT   =%1000          ;BIT 3 IS ENABLE/DISABLE TO DECOD
0035   A64F              ;
0036   A64F              ;EQUATES
0037   A64F              ;
0038   A64F              P2SCR   =$829C          ;MOVE P2 TO $FF,$FE IN PAGE ZERO
0039   A64F              ZERCK   =$832E          ;ZERO OUT CHECK SUM
0040   A64F              CONFIG  =$89A5
0041   A64F              ;
0042   A64F              ID      = P1L
0043   A64F              SAH     = P2H
0044   A64F              SAL     = P2L
0045   A64F              EAH     = P3H
0046   A64F              EAL     = P3L
0047   A64F              ;
0048   A64F              FRAME   =$FF            ;ERROR MSG # FOR FRAMING ERROR
0049   A64F              CHECK   =$CC            ;ERROR # FOR CHECKSUM ERROR
0050   A64F              LSTCHR  =$2F            ;LAST CHAR NOT '/'
0051   A64F              NONHEX  =$FF            ;NON HEX CHAR IN KIM REC
0052   A64F              ;
0053   A64F              ;I/O    TAPE ON/OFF IS CB2 ON VIA 1 (A000)
0054   A64F              ;       TAPE IN IS PB6 ON VIA 1 (A000)
0055   A64F              ;       TAPE OUT IS CODE 7 TO DISPLAY DECODER, THRU 6532:
0056   A64F              ;            PB0-PB3 (A400)
```

```
LINE # LOC      CODE        LINE

0057  A64F                ;
0058  A64F                VIAACR =$A00B
0059  A64F                VIAPCR =$A00C           ;CONTROL CB2 TAPE ON/OFF, POR
0060  A64F                TPOUT  =$A402
0061  A64F                TAPOUT =TPOUT
0062  A64F                DDROUT =$A403
0063  A64F                TAPIN  =$A000
0064  A64F                DDRIN  =$A002
0065  A64F                CLOKHI =$A005
0066  A64F                CLOKLO =$A004
0067  A64F                LATCHL =$A004
0068  A64F                DDRDIG =$A401
0069  A64F                DIG    =$A400
0070  A64F                ; LOADT ENTER W/ ADDR IN PARM 2, MODE IN ACC
0071  A64F                ;
0072  A64F                      *=$8C78
0073  8C78  20 B6 8D    LOADT  JSR START       ;INITIALIZE
0074  8C7B  AD 02 A0           LDA DDRIN
0075  8C7E  29 BF              AND #$BF        ;BIT 6 = 0, INPUT IS PB6
0076  8C80  8D 02 A0           STA DDRIN
0077  8C83  A9 00              LDA #0
0078  8C85  8D 0B A0           STA VIAACR
0079  8C88  A9 AE              LDA #CKIM       ; SET UP CLOCK FOR GETTR (KIM)
0080  8C8A  24 FD              BIT MODE
0081  8C8C  10 02              BPL LOADT1      ;KIM - GO AHEAD
0082  8C8E  A9 1F              LDA #C1500      ;HS - CHANGE GETTR VALUE
0083  8C90  8D 04 A0    LOADT1 STA LATCHL      ;STORE GETTR VAL IN LO LATCH
0084  8C93  20 82 8D    LOADT2 JSR SYNC        ;GET IN SYNC
0085  8C96  20 DE 8D    LOADT4 JSR RDCHTX
0086  8C99  C9 2A              CMP #'*         ;START OF DATA?
0087  8C9B  F0 06              BEQ LOAD11
0088  8C9D  C9 16              CMP #SYN        ;NO - SYN?
0089  8C9F  D0 F2              BNE LOADT2      ;IF NOT, RESTART SYNC SEARCH
0090  8CA1  F0 F3              BEQ LOADT4      ;IF YES, KEEP LOOKING FOR *
0091  8CA3                ;
0092  8CA3  A5 FD        LOAD11 LDA MODE
0093  8CA5  29 BF              AND #$BF        ;CLEAR 'NOT IN SYNC' BIT
0094  8CA7  85 FD              STA MODE
0095  8CA9  20 28 8E           JSR RDBYTX      ;READ ID BYTE ON TAPE
0096  8CAC  CD 4E A6           CMP ID          ;COMPARE WITH REQUESTED ID
0097  8CAF  F0 35              BEQ LOADT5      ;LOAD IF EQUAL
0098  8CB1  AD 4E A6           LDA ID          ;COMPARE WITH 0
0099  8CB4  C9 00              CMP #0
0100  8CB6  F0 2E              BEQ LOADT5      ;IF 0, LOAD ANYWAY
0101  8CB8  C9 FF              CMP #$FF        ;COMPARE WITH FF
0102  8CBA  F0 07              BEQ LOADT6      ;IF FF, USE REQUEST SA TO LOAD
0103  8CBC                ;
0104  8CBC  24 FD              BIT MODE        ;UNWANTED RECORD. KIM OR HS?
0105  8CBE  30 22              BMI HWRONG
0106  8CC0  4C 93 8C           JMP LOADT2      ;IF KIM, RESTART SEARCH
0107  8CC3                ;
0108  8CC3                ; SA (&EA IF USED) COME FROM REQUEST. DISCARD TAPE VALUE!
0109  8CC3                ;   (BUFAD ALREADY SET TO SA BY 'START')
0110  8CC3                ;
0111  8CC3  20 28 8E    LOADT6 JSR RDBYTX      ;GET SAL FROM TAPE
```

```
LINE # LOC      CODE        LINE

0112  8CC6  20 78 8E            JSR CHKT          ;INCLUDE IN CHECKSUM BUT IGNORE
0113  8CC9
0114  8CC9  20 28 8E            JSR RDBYTX        ;GET SAH FROM TAPE
0115  8CCC  20 78 8E            JSR CHKT          ;INCLUDE IN CHECKSUM
0116  8CCF                  ;
0117  8CCF  24 FD            HWRONG BIT MODE       ;HS OR KIM?
0118  8CD1  10 63                   BPL LOADT7     ;IF KIM, START READING DATA
0119  8CD3  20 E2 8D            JSR RDBYTH        ;HS. GET EAH, EAL FROM ...
0120  8CD6  20 78 8E            JSR CHKT          ; ... TAPE, INCLUDE IN CHECKSUM
0121  8CD9  20 E2 8D            JSR RDBYTH        ; ... BUT IGNORE
0122  8CDC  20 78 8E            JSR CHKT
0123  8CDF  4C 0C 8D            JMP LT7H          ;START READING HS DATA
0124  8CE2                  ;
0125  8CE2                  ; SA (& EA IF USED) COME FROM TAPE. SA REPLACES BUFAD
0126  8CE2                  ;
0127  8CE2  A9 C0            HWRONG LDA #$C0       ;READ THRU TO GET TO NEXT REC
0128  8CE4  85 FD                   STA MODE       ;BUT DON'T CHECK CKSUM, NO FRAME I
0129  8CE6                  ;
0130  8CE6  20 28 8E            LOADT5 JSR RDBYTX     ;GET SAL FROM TAPE
0131  8CE9  20 78 8E                   JSR CHKT
0132  8CEC  85 FE                   STA BUFADL     ;PUT IN BUF START L
0133  8CEE  20 28 8E            JSR RDBYTX        ;SAME FOR SAH
0134  8CF1  20 78 8E            JSR CHKT
0135  8CF4  85 FF                   STA BUFADH
0136  8CF6                      ;(SAL - H STILL HAVE REQUEST VALUE)
0137  8CF6  24 FD                   BIT MODE       ;HS OR KIM?
0138  8CF8  10 3C                   BPL LOADT7     ;IF KIM, START READING RECORD
0139  8CFA  20 E2 8D            JSR RDBYTH        ;HS. GET & SAVE EAL,EAH
0140  8CFD  20 78 8E            JSR CHKT
0141  8D00  8D 4A A6            STA EAL
0142  8D03  20 E2 8D            JSR RDBYTH
0143  8D06  20 78 8E            JSR CHKT
0144  8D09  8D 4B A6            STA EAH
0145  8D0C                  ;
0146  8D0C                  ; READ HS DATA
0147  8D0C                  ;
0148  8D0C  20 E2 8D            LT7H   JSR RDBYTH     ;GET NEXT BYTE
0149  8D0F  A6 FE                   LDX BUFADL     ;CHECK FOR END OF DATA + 1
0150  8D11  EC 4A A6                CPX EAL
0151  8D14  D0 07                   BNE LT7HA
0152  8D16  A6 FF                   LDX BUFADH
0153  8D18  EC 4B A6                CPX EAH
0154  8D1B  F0 13                   BEQ LT7HB
0155  8D1D  20 78 8E            LT7HA  JSR CHKT       ;NOT END. UPDATE CHECKSUM
0156  8D20  24 FD                   BIT MODE       ;WRONG RECORD?
0157  8D22  70 04                   BVS LT7HC      ;IF SO, DONT STORE BYTE
0158  8D24  A0 00                   LDY #0         ;STORE BYTE
0159  8D26  91 FE                   STA (BUFADL),Y
0160  8D28  E6 FE            LT7HC  INC BUFADL     ;BUMP BUFFER ADDR
0161  8D2A  D0 E0                   BNE LT7H
0162  8D2C  E6 FF                   INC BUFADH     ;CARRY
0163  8D2E  D0 DC                   BNE LT7H       ;ALWAYS
0164  8D30                  ;
0165  8D30  C9 2F            LT7HB  CMP #'/        ;EA, MUST BE "/"
0166  8D32  D0 31                   BNE LCERR      ;LAST CHAR NOT '/'
```

```
LINE # LOC      CODE        LINE

0167  8D34  F0 19            BEQ LOADT8       ;(ALWAYS BRANCH)
0168  8D36                  ;
0169  8D36                  ; READ KIM DATA
0170  8D36                  ;
0171  8D36  20 2C 8E     LOADT7 JSR RDBYT
0172  8D39  B0 2E            BCS NHERR        ;NONHEX CHAR?
0173  8D3B  C9 2F            CMP #'/          ;LAST ?
0174  8D3D  F0 10            BEQ LOADT8
0175  8D3F  20 78 8E         JSR CHKT         ;UPDATE CHECKSUM (PACKED BYTE)
0176  8D42  A0 00            LDY #0           ;STORE BYTE
0177  8D44  91 FE            STA (BUFADL),Y
0178  8D46  E6 FE            INC BUFADL       ;BUMP BUFFER ADR
0179  8D48  D0 EC            BNE LOADT7       ;CARRY?
0180  8D4A  E6 FF            INC BUFADH
0181  8D4C  4C 36 8D         JMP LOADT7
0182  8D4F                  ;
0183  8D4F                  ; TEST CHECKSUM & FINISH
0184  8D4F                  ;
0185  8D4F                  LOADT8 =*
0186  8D4F  20 28 8E     LT8A   JSR RDBYTX       ;CHECK SUM
0187  8D52  CD 36 A6            CMP CHKL
0188  8D55  D0 16               BNE CKERR
0189  8D57  20 28 8E            JSR RDBYTX
0190  8D5A  CD 37 A6            CMP CHKH
0191  8D5D  D0 0E               BNE CKERR        ;CHECK SUM ERROR
0192  8D5F  F0 11               BEQ OKEXIT       ;(ALWAYS)
0193  8D61                  ;
0194  8D61  A9 FF        FRERR  LDA #FRAME       ;FRAMING ERROR
0195  8D63  D0 0A               BNE NGEXIT       ;(ALWAYS)
0196  8D65  A9 2F        LCERR  LDA #LSTCHR      ;LAST CHAR IS NOT '/'
0197  8D67  D0 06               BNE NGEXIT       ;(ALWAYS)
0198  8D69                  ;
0199  8D69  A9 FF        NHERR  LDA #NONHEX      ;KIM ONLY, NON HEX CHAR READ
0200  8D6B  D0 02               BNE NGEXIT       ;(ALWAYS)
0201  8D6D                  ;
0202  8D6D  A9 CC        CKERR  LDA #CHECK       ;CHECKSUM ERROR
0203  8D6F                  ;
0204  8D6F  38           NGEXIT SEC              ;ERROR INDICATOR TO MONITOR IS CAF
0205  8D70  B0 01               BCS EXIT         ;(ALWAYS)
0206  8D72                  ;
0207  8D72  18           OKEXIT CLC              ;NO ERROR
0208  8D73                  ;
0209  8D73  24 FD        EXIT   BIT MODE
0210  8D75  50 05               BVC EX10         ;READING WRONG REC?
0211  8D77  A0 80               LDY #$80
0212  8D79  4C 78 8C            JMP LOADT        ;RESTART SEARCH
0213  8D7C  A2 CC        EX10   LDX #$CC
0214  8D7E  8E 0C A0            STX VIAPCR       ;STOP TAPE
0215  8D81  60                 RTS
0216  8D82  A9 6D        SYNC   LDA #$6D
0217  8D84  8D 00 A4            STA DIG          ;TURN ON OUT OF SYNC INDICATOR
0218  8D87  A5 FD               LDA MODE         ;TURN ON OUT OF SYNC MODE
0219  8D89  09 40               ORA #$40         ;BIT6
0220  8D8B  85 FD               STA MODE
0221  8D8D  20 A8 8D        SYNC5  JSR SYNBIT       ; SYNC TO TAPE
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```
LINE # LOC      CODE        LINE

0222  8D90  66 FC           ROR CHAR
0223  8D92  A5 FC           LDA CHAR
0224  8D94  C9 16           CMP #SYN
0225  8D96  D0 F5           BNE SYNC5
0226  8D98  A2 0A     SYNC10 LDX #10          ;NOW MAKE SURE CAN GET 10 SYNS
0227  8D9A  20 DE 8D        JSR RDCHTX
0228  8D9D  C9 16           CMP #SYN
0229  8D9F  D0 EC           BNE SYNC5
0230  8DA1  CA              DEX
0231  8DA2  D0 F6           BNE SYNC10+2
0232  8DA4  8E 00 A4        STX DIG           ;TURN OFF DISPLAY
0233  8DA7  60              RTS
0234  8DA8              ;SYNBIT   GET BIT IN SYN SEARCH. IF HS, ENTER WITH
0235  8DA8              ;  TIMER STARTED BY PREV BIT. BIT RETURNED IN CARRY.
0236  8DA8              ;
0237  8DA8  24 FD       SYNBIT BIT MODE         ;KIM OR HS?
0238  8DAA  10 63           BPL RDBITK         ;KIM
0239  8DAC  20 C9 8D    SYB10  JSR GETTR        ;HS
0240  8DAF  B0 01           BCS SYBONE         ;IF SHORT, GET NEXT TRANS
0241  8DB1  60              RTS                ;BIT IS ZERO
0242  8DB2  20 C9 8D    SYBONE JSR GETTR
0243  8DB5  60              RTS
0244  8DB6              ;
0245  8DB6  84 FD       START  STY MODE         ;MODE PARM PASSED IN ACC
0246  8DB8  A9 09           LDA #9
0247  8DBA  20 A5 89        JSR CONFIG         ;PARTIAL I/O CONFIGURATION
0248  8DBD  20 2E 83        JSR ZERCK          ;ZERO THE CHECK SUM
0249  8DC0  20 9C 82        JSR P2SCR          ;MOVE SA TO FE,FF IN PAGE ZERO
0250  8DC3  A9 EC           LDA #$EC
0251  8DC5  8D 0C A0        STA VIAPCR         ;TAPE ON
0252  8DC8  60              RTS
0253  8DC9              ;
0254  8DC9              ; GETTR - GET TRANSITION TIME FROM 16 BIT CLOCK
0255  8DC9              ; DESTROYS A,Y
0256  8DC9              ; LO LATCH OF CLOCK MUST BE PRELOADED ACCORDING TO MODE
0257  8DC9              ; SO THAT LSB OF HI BYTE OF CTR =BIT (HS)
0258  8DC9              ;       OR LSB OF HI BYTE IS 1/0 HF/LF  (KIM)
0259  8DC9              ; LSB OF HI CLOCK BYTE RETURNED IN CARRY
0260  8DC9              ;
0261  8DC9  A0 FF       GETTR  LDY #$FF
0262  8DCB  AD 00 A0           LDA TAPIN
0263  8DCE  29 40              AND #$40
0264  8DD0  C5 F9              CMP OLD
0265  8DD2  F0 F7              BEQ GETTR+2
0266  8DD4  85 F9              STA OLD
0267  8DD6  AD 05 A0           LDA CLOKHI
0268  8DD9  8C 05 A0           STY CLOKHI         ;RESTART CLOCK
0269  8DDC  4A                 LSR A              ;GET LSB INTO CARRY
0270  8DDD  60                 RTS
0271  8DDE              ;
0272  8DDE  24 FD       RDCHTX BIT MODE
0273  8DE0  10 7F           BPL RDCHT          ;KIM
0274  8DE2              ;
0275  8DE2              ; RDBYTH - READ HS BYTE
0276  8DE2              ;Y DESTROYED, BYTE RETURNED IN CHAR AND A
```

```
LINE #  LOC    CODE        LINE

0387  8E82  EE 37 A6          INC CHKH        ;BUMP HI BYTE
0388  8E85  98           CHKT10 TYA             ;RESTORE A
0389  8E86  60                 RTS
0390  8E87  20 B6 8D     DUMPT  JSR START       ;INIT VIA & CKSUM, SA TO BUFAD & S
0391  8E8A  A9 07               LDA #7          ;CODE FOR TAPE OUT
0392  8E8C  8D 02 A4            STA TAPOUT      ;BIT 3 USED FOR HI/LO
0393  8E8F  A0 80               LDY #$80
0394  8E91  24 FD               BIT MODE
0395  8E93  10 13               BPL DUMPT1      ;KIM - DO 128 SYNS
0396  8E95                 ;HS:  WRITE 8 SEC STEADY MARK
0397  8E95  EE 02 A4            INC TAPOUT      ;DISABLE OUTPUT
0398  8E98  A2 08               LDX #$8         ;8 TIMES ...
0399  8E9A  A0 15         MARK8A LDY #21        ;... 1SEC
0400  8E9C  20 5D 8F     MARK8B JSR OUTCHT      ;BENIGN PAUSE
0401  8E9F  88                 DEY
0402  8EA0  D0 FA               BNE MARK8B
0403  8EA2  CA                 DEX
0404  8EA3  D0 F5               BNE MARK8A
0405  8EA5  CE 02 A4            DEC TAPOUT      ;RESTORE OUTPUT
0406  8EA8                 ; AND DO 256 SYNS
0407  8EA8  A9 16         DUMPT1 LDA #SYN
0408  8EAA  20 13 8F            JSR OUTCTX      ;WRITE SYN
0409  8EAD  88                 DEY
0410  8EAE  D0 F8               BNE DUMPT1
0411  8EB0                 ;
0412  8EB0  A9 2A               LDA #'*         ;WRITE START
0413  8EB2  20 13 8F            JSR OUTCTX
0414  8EB5
0415  8EB5  AD 4E A6            LDA ID          ;WRITE ID
0416  8EB8  20 46 8F            JSR OUTBTX
0417  8EBB
0418  8EBB  AD 4C A6            LDA SAL         ;WRITE SA
0419  8EBE  20 43 8F            JSR OUTBCX
0420  8EC1  AD 4D A6            LDA SAH
0421  8EC4  20 43 8F            JSR OUTBCX
0422  8EC7                 ;
0423  8EC7                 ;
0424  8EC7  24 FD               BIT MODE        ;KIM OR HS?
0425  8EC9  10 0C               BPL DUMPT2
0426  8ECB                 ;
0427  8ECB  AD 4A A6            LDA EAL         ;HS. WRITE EA
0428  8ECE  20 43 8F            JSR OUTBCX
0429  8ED1  AD 4B A6            LDA EAH
0430  8ED4  20 43 8F            JSR OUTBCX
0431  8ED7                 ;
0432  8ED7  A5 FE         DUMPT2 LDA BUFADL     ;CHECK FOR LAST BYTE
0433  8ED9  CD 4A A6            CMP EAL
0434  8EDC  D0 25               BNE DUMPT4
0435  8EDE  A5 FF               LDA BUFADH
0436  8EE0  CD 4B A6            CMP EAH
0437  8EE3  D0 1E               BNE DUMPT4
0438  8EE5                 ;
0439  8EE5  A9 2F               LDA #'/         ;LAST. WRITE '/'
0440  8EE7  20 13 8F            JSR OUTCTX
0441  8EEA  AD 36 A6            LDA CHKL        ;WRITE CHECK SUM
```

```
LINE # LOC     CODE        LINE

0442  8EED  20 46 8F          JSR OUTBTX
0443  8EF0  AD 37 A6          LDA CHKH
0444  8EF3  20 46 8F          JSR OUTBTX
0445  8EF6
0446  8EF6  A9 04             LDA #EOT          ;WRITE TWO EOT'S
0447  8EF8  20 46 8F          JSR OUTBTX
0448  8EFB  A9 04             LDA #EOT
0449  8EFD  20 46 8F          JSR OUTBTX
0450  8F00                  ;
0451  8F00                  DT3E    = * (SET "OK" MARK)
0452  8F00  4C 72 8D          JMP OKEXIT
0453  8F03                  ;
0454  8F03  A0 00           DUMPT4 LDY #0            ;GET BYTE
0455  8F05  B1 FE                 LDA (BUFADL),Y
0456  8F07  20 43 8F          JSR OUTBCX        ;WRITE IT W/CHK SUM
0457  8F0A  E6 FE             INC BUFADL        ;BUMP BUFFER ADDR
0458  8F0C  D0 C9             BNE DUMPT2
0459  8F0E  E6 FF             INC BUFADH        ;CARRY
0460  8F10  4C D7 8E          JMP DUMPT2
0461  8F13  24 FD           OUTCTX BIT MODE          ;HS OR KIM?
0462  8F15  10 46             BPL OUTCHT        ;KIM
0463  8F17                  ;
0464  8F17                  ;  OUTBTH - NO CLOCK
0465  8F17                  ; A,X DESTROYED
0466  8F17                  ; MUST RESIDE ON ONE PAGE - TIMING CRITICAL
0467  8F17  A2 09           OUTBTH LDX #9            ;8 BITS + START BIT
0468  8F19  8C 39 A6             STY TEMP2
0469  8F1C  85 FC             STA CHAR
0470  8F1E  AD 02 A4             LDA TAPOUT        ;GET PREV LEVEL
0471  8F21  46 FC           GETBIT LSR CHAR
0472  8F23  49 08                 EOR #TPBIT
0473  8F25  8D 02 A4             STA TAPOUT        ;INVERT LEVEL
0474  8F28                  ; *** HERE STARTS FIRST 416 USEC PERIOD
0475  8F28  A0 47                LDY #TM1500
0476  8F2A  88               A416   DEY               ;TIME FOR THIS LOOP IS 5Y-1
0477  8F2B  D0 FD                 BNE A416
0478  8F2D  90 11                BCC NOFLIP        ;NOFLIP IF BIT ZERO
0479  8F2F  49 08                EOR #TPBIT        ;BIT IS ONE - INVERT OUTPUT
0480  8F31  8D 02 A4             STA TAPOUT
0481  8F34                  ; *** END OF FIRST 416 USEC PERIOD
0482  8F34  A0 46           B416   LDY #TM1500-1
0483  8F36  88              B416B  DEY               ;LENGTH OF LOOP IS 5Y-1
0484  8F37  D0 FD                 BNE B416B
0485  8F39  CA                    DEX
0486  8F3A  D0 E5                BNE GETBIT        ;GET NEXT BIT (LAST IS 0 START BI
0487  8F3C  AC 39 A6             LDY TEMP2         ; (BY 9 BIT LSR)
0488  8F3F  60                   RTS
0489  8F40  EA              NOFLIP NOP               ;TIMING
0490  8F41  90 F1                BCC B416          ;(ALWAYS)
0491  8F43                  ;
0492  8F43  20 78 8E        OUTBCX JSR CHKT
0493  8F46  24 FD           OUTBTX BIT MODE
0494  8F48  30 CD                 BMI OUTBTH        ;HS
0495  8F4A                  ;
0496  8F4A                  ;OUTBTC - OUTPUT ONE KIM BYTE
```

```
LINE # LOC     CODE        LINE

0497  8F4A
0498  8F4A                OUTBTC =*
0499  8F4A  A8            OUTBT  TAY              ;SAVE DATA BYTE
0500  8F4B  4A                   LSR A
0501  8F4C  4A                   LSR A
0502  8F4D  4A                   LSR A
0503  8F4E  4A                   LSR A
0504  8F4F  20 52 8F            JSR HEXOUT       ;MORE SIG DIGIT
0505  8F52                ; FALL INTO HEXOUT
0506  8F52                ;
0507  8F52                ;CONVERT LSD OF A TO ASCII
0508  8F52                ;
0509  8F52  29 0F         HEXOUT AND #$0F
0510  8F54  C9 0A                CMP #$0A
0511  8F56  18                   CLC
0512  8F57  30 02                BMI HEX1
0513  8F59  69 07                ADC #$07
0514  8F5B  69 30         HEX1   ADC #$30
0515  8F5D                ;
0516  8F5D                ; OUTCHT - OUTPUT ASCII CHAR (KIM)
0517  8F5D                ; CLOCK NOT USED
0518  8F5D                ; X,Y PRESERVED
0519  8F5D                ; MUST RESIDE ON ONE PAGE - TIMING CRITICAL
0520  8F5D                ;
0521  8F5D  8E 38 A6      OUTCHT STX TEMP1        ;PRESERVE X
0522  8F60  8C 39 A6             STY TEMP2        ;DITTO Y
0523  8F63  85 FC                STA CHAR
0524  8F65  A9 FF                LDA #$FF         ;USE FF W/SHIFTS TO COUNT BITS
0525  8F67  48            KIMBIT PHA              ;SAVE BIT CTR
0526  8F68  AD 02 A4             LDA TPOUT        ;GET CURRENT OUTPUT LEVEL
0527  8F6B  46 FC                LSR CHAR         ;GET DATA BIT IN CARRY
0528  8F6D  A2 12                LDX #18          ;ASSUME 'ONE'
0529  8F6F  B0 02                BCS HF
0530  8F71  A2 24                LDX #36          ;BIT IS ZERO
0531  8F73  A0 19         HF     LDY #25
0532  8F75  49 08                EOR #TPBIT       ;INVERT OUTPUT
0533  8F77  8D 02 A4             STA TPOUT
0534  8F7A  88            HFP1   DEY              ;PAUSE FOR 138 USEC
0535  8F7B  D0 FD                BNE HFP1
0536  8F7D  CA                   DEX              ;COUNT HALF CYCS OF HF
0537  8F7E  D0 F3                BNE HF
0538  8F80  A2 18         LF     LDX #24          ;ASSUME BIT IS ONE
0539  8F82  B0 02                BCS LF20
0540  8F84  A2 0C                LDX #12          ;BIT IS ZERO
0541  8F86  A0 27         LF20   LDY #39
0542  8F88  49 08                EOR #TPBIT      ;INVERT OUTPUT
0543  8F8A  8D 02 A4             STA TPOUT
0544  8F8D  88            LFP1   DEY              ;PAUSE FOR 208 USEC
0545  8F8E  D0 FD                BNE LFP1
0546  8F90  CA                   DEX              ;COUNT HALF CYCS
0547  8F91  D0 F3                BNE LF20
0548  8F93  68                   PLA              ;RESTORE BIT CTR
0549  8F94  0A                   ASL A            ;DECREMENT IT
0550  8F95  D0 D0                BNE KIMBIT       ;FF SHIFTED 8X = 00
0551  8F97  AE 38 A6             LDX TEMP1
```

```
LINE # LOC      CODE        LINE

0552  8F9A  AC 39 A6            LDY TEMP2
0553  8F9D  98                  TYA                 ;RESTORE DATA BYTE
0554  8F9E  60                  RTS'
0555  8F9F                ;
0556  8F9F                      .END

ERRORS = 0000 <0000>
```

SYMBOL	VALUE	LINE DEFINED		CROSS-REFERENCES								
A208	8F2A	476	477									
BUFADH	00FF	15	135	152	162	180	435	459				
BUFADL	00FE	14	132	149	159	160	177	178	432	455	457	
B208	8F34	482	490									
B208B	8F36	483	484									
CHAR	00FC	10	222	223	290	293	331	352	355	369	373	469
			471	523	527							
CHECK	00CC	49	202									
CHKH	A637	17	190	387	443							
CHKL	A636	16	187	384	385	441						
CHKT	8E78	382	112	115	120	122	131	134	140	143	155	175
			492									
CHKT10	8E85	388	386									
CKERR	8D6D	202	188	191								
CKIM	00AE	33	79									
CLOKHI	A005	65	267	268								
CLOKLO	A004	66	****									
CONFIG	89A5	40	247									
C1500	001F	32	82									
DDRDIG	A401	68	****									
DDRIN	A002	64	74	76								
DDROUT	A403	62	****									
DIG	A400	69	217	232								
DT3E	8F00	451	****									
DUMPT	8E87	390	****									
DUMPT1	8EA8	407	395	410								
DUMPT2	8ED7	432	425	458	460							
DUMPT4	8F03	454	434	437								
EAH	A64B	45	144	153	429	436						
EAL	A64A	46	141	150	427	433						
EOT	0004	29	446	448								
EXIT	8D73	209	205									
EX10	8D7C	213	210									
FRAME	00FF	48	194	300								
FRERR	8D61	194	****									
GETBIT	8F21	471	486									
GETTR	8DC9	261	239	242	265	282	286	288	307	308	314	
HEXOUT	8F52	509	504									
HEX1	8F5B	514	512									
HF	8F73	531	529	537								
HFCNT	8E1C	313	315									
HFP1	8F7A	534	535									
HWRONG	8CE2	127	105									
ID	A64E	42	96	98	415							
KBITS	8E66	367	372									
KIMBIT	8F67	525	550									
LATCHL	A004	67	83									
LCERR	8D65	196	166									
LF	8F80	538	****									
LFP1	8F8D	544	545									
LF20	8F86	541	539	547								
LOADT	8C78	73	212									
LOADT1	8C90	83	81									
LOADT2	8C93	84	89	106								

SYMBOL	VALUE	LINE DEFINED		CROSS-REFERENCES								
LOADT4	8C96	85	90									
LOADT5	8CE6	130	97	100								
LOADT6	8CC3	111	102									
LOADT7	8D36	171	118	138	179	181						
LOADT8	8D4F	185	167	174								
LOAD11	8CA3	92	87									
LSTCHR	002F	50	196									

SYMBOL	VALUE	LINE DEFINED	CROSS-REFERENCES
LT7H	8D0C	148	123 161 163
LT7HA	8D1D	155	151
LT7HB	8D30	165	154
LT7HC	8D28	160	157
LT8A	8D4F	186	****
MARK8A	8E9A	399	404
MARK8B	8E9C	400	402
MODE	00FD	11	80 92 94 104 117 128 137 156 209 218 220 237 245 272 296 320 394 424 461 493
NGEXIT	8D6F	204	195 197 200 301
NHERR	8D69	199	172
NOFLIP	8F40	489	478
NONHEX	00FF	51	199
OKEXIT	8D72	207	192 452
OLD	00F9	9	264 266
OUTBCX	8F43	492	419 421 428 430 456
OUTBT	8F4A	499	****
OUTBTC	8F4A	498	****
OUTBTH	8F17	467	494
OUTBTX	8F46	493	416 442 444 447 449
OUTCHT	8F5D	521	400 462
OUTCTX	8F13	461	408 413 440
PACKT	8E3E	337	327
PACKT1	8E4F	346	343
PACKT2	8E55	351	354
PACKT3	8E5F	358	318 338 340 342
P1L	A64E	26	42
P2H	A64D	25	43
P2L	A64C	24	44
P2SCR	829C	38	249
P3H	A64B	23	45
P3L	A64A	22	46
RDASSY	8DF9	290	287
RDBH10	8DEF	286	292
RDBH90	8E04	296	285 289 297
RDBITK	8E0F	306	238 368
RDBYT	8E2C	324	171
RDBYTH	8DE2	280	119 121 139 142 148 321
RDBYTX	8E28	320	95 111 114 130 133 186 189
RDCHT	8E61	365	273 324 330
RDCHTX	8DDE	272	85 227
RDRTN	8E5E	357	317 326 328
SAH	A64D	43	420
SAL	A64C	44	418
START	8DB6	245	73 390
SYBONE	8DB2	242	240
SYB10	8DAC	239	****
SYN	0016	30	88 224 228 407
SYNBIT	8DA8	237	221
SYNC	8D82	216	84
SYNC10	8D98	226	231
SYNC5	8D8D	221	225 229
TAPIN	A000	63	262
TAPOUT	A402	61	392 397 405 470 473 480
TEMP1	A638	18	280 294 365 376 521 551
TEMP2	A639	19	468 487 522 552
TM1500	0047	31	475 482
TPBIT	0008	34	472 479 532 542
TPOUT	A402	60	61 526 533 543
VIAACR	A00B	58	78
VIAPCR	A00C	59	214 251
WAITLO	8E14	308	309 311
ZERCK	832E	39	248

NOTES

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Synertek Systems Corporation

P.O. BOX 552 SANTA CLARA, CALIFORNIA 95052 TEL. (408) 988-5600 TWX: 910-338-0135